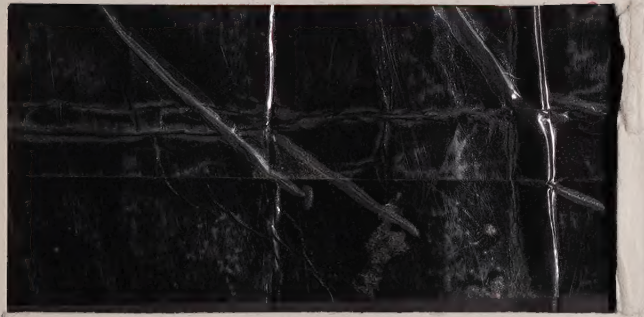


OPERATING AND SERVICE MANUAL

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OPERATING MANUAL

MODEL K500-D LOGIC ANALYZER

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OPERATING MANUAL

MODEL K500-D LOGIC ANALYZER

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OPERATING MANUAL
MODEL K500-D LOGIC ANALYZER

NOTICE

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OPERATING MANUAL
MODEL K500-D LOGIC ANALYZER

WARNING: THIS EQUIPMENT GENERATES, USES, AND CAN RADIATE RADIO FREQUENCY ENERGY, AND IF NOT INSTALLED AND USED IN ACCORDANCE WITH THE INSTRUCTION MANUAL, MAY CAUSE INTERFERENCE TO RADIO COMMUNICATIONS. AS TEMPORARILY PERMITTED BY REGULATION, IT HAS NOT BEEN TESTED FOR COMPLIANCE WITH THE LIMITS FOR CLASS A COMPUTING DEVICES PURSUANT TO SUBPART J OF PART 15 OF FCC RULES, WHICH ARE DESIGNED TO PROVIDE REASONABLE PROTECTION AGAINST SUCH INTERFERENCE. OPERATION OF THIS EQUIPMENT IN A RESIDENTIAL AREA IS LIKELY TO CAUSE INTERFERENCE IN WHICH CASE, THE USER AT HIS OWN EXPENSE, WILL BE REQUIRED TO TAKE THE MEASURES WHICH MAY BE REQUIRED TO CORRECT THE INTERFERENCE.

OPERATING MANUAL

MODEL K500-D LOGIC ANALYZER

SECTION I

GENERAL INFORMATION

1.1 Certification

Gould Inc. certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory.

1.2 Warranty

All Gould Inc. products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products that prove to be defective during the warranty period. If a unit fails within thirty days of delivery, Gould Inc. will pay all shipping charges relating to the repair of the unit. Units under warranty, but beyond the thirty day period, should be sent to Gould Inc. prepaid and Gould Inc. will return the unit prepaid. Units out of the one year warranty period, the customer will pay all freight charges. IN THE EVENT OF A BREACH OF GOULD INC.'S WARRANTY, GOULD INC. SHALL HAVE THE RIGHT IN ITS DISCRETION EITHER TO REPLACE OR REPAIR THE DEFECTIVE GOODS OR TO REFUND THE PORTION OF THE PURCHASE PRICE APPLICABLE THERETO. THERE SHALL BE NO OTHER REMEDY FOR BREACH OF THE WARRANTY. IN NO EVENT SHALL GOULD INC. BE LIABLE FOR THE COST OF PROCESSING, LOST PROFITS, INJURY TO GOODWILL, OR ANY SPECIAL OR CONSEQUENTIAL DAMAGES. THE FOREGOING WARRANTY IS EXCLUSIVE OF ALL OTHER WARRANTIES, WHETHER EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OR MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

1.3 Description

The Model K500-D Logic Analyzer is a significant tool for design and development of high speed digital circuitry such as mainframe and super mini-computers, and real-time processors. A specific set of features have been integrated into one instrument to allow the user to concentrate on problem solving when working with very high speed digital circuitry, or complex high performance computer architecture, rather than being concerned about having the proper set of tools.

The K500-D not only provides a significant increase in measurement resolution, but also delivers a combination of technological advances and convenience features.

The Model K500-D Logic Analyzer represents a new era in flexibility. With the comprehensive recording and display analysis capabilities of the instrument, you can perform complex timing and state analysis of your digital systems. The unit has three distinct features that make it a useful tool for logic troubleshooting.

First, the signals from your system are input via specially designed hybrid active probes. The input impedance of each probe is 25 k Ω , 3 pF. The probes are individual to allow you to span physically separated points in your system, and also provide for convenient connection at the PC board level. Signal conditioning, or threshold detection, and buffering of the signal is provided at a point as close as possible to the circuitry. The probes detect logic spikes or glitches down to 2 ns, regardless to clock rate used.

Second, the instrument can clock at rates to 500 MHz, allowing you to make timing measurements on up to 8 digital signals with a 2 ns time resolution. Analog recordings are also made at a 500 MHz sample rate using a built-in 4 bit ADC. A 2000 word memory allows precise timing measurements to be made over long intervals of time. The performance of the active probes complement the high speed recording capability.

Third, the instrument uses a microprocessor linked to the front keyboard for instrument control. Comprehensive display prompting is used to make it easy to set up the unit for desired recording and display formats. This provides a greater degree of flexibility in recording and display functions than was possible with earlier instruments.

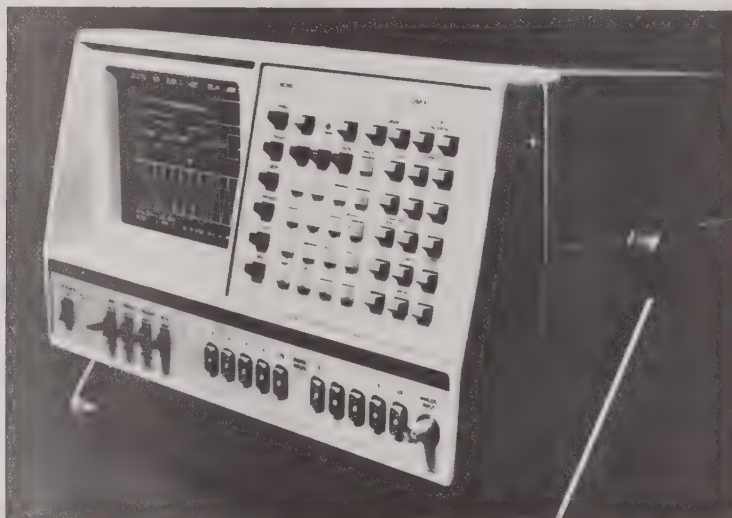


Figure 1.1 The Model K500-D Logic Analyzer is a technological breakthrough in logic analysis, with 500 MHz clocking, 2000 word memory, 8 digital signal inputs, an analog waveform digitizer input, unique scroll acquisition mode, and comprehensive time and data domain analysis facilities.

1.4 Specifications

SIGNAL INPUTS

Digital

Number. 10, including 8 data, external clock, and 1 trigger qualifier.

Impedance. 25 k Ω /3.0 pF (2.7 pF nominal) at tip of active probe.

Threshold. Each input may be assigned one of four references: TTL (+1.4 V), ECL (-1.3 V), VAR A, VAR B; A & B selectable between -6.35 V and +6.30 V, in 50 mV increments. Thresholds are references to probe tip. High or low true logic polarity is selectable for each channel.

Maximum Voltage. ± 20 V continuous, ± 50 V transient.

Modes. Sample or Latch input mode on a per channel basis.

Sample. Unit stores the detected logic level present at each active clock transition simultaneously on all inputs. Minimum pulse width always detected and stored is one clock period plus 1 ns.

Latch. Whenever an even number of threshold transitions occur between two successive clock intervals, an input latch stores the state opposite that stored at the previous clock interval on the next clock. The latch mode is non-functional at the 2 ns clock interval, since the sample period equals the glitch capture at that sample rate. When LATCH is selected at any clock rate, a glitch will be recorded at 2 memory locations. Latch is functional at clock rates from 50 ms to 5 ns.

Minimum Detectable Pulse In Latch. 2 ns with threshold overdrive of 25% of total voltage swing, or 250 mV, whichever is greater.

Analog

Number. 1 input via a front panel BNC.

Impedance. 10 M Ω /13 pF nominal at the tip of 10:1 probe. 1 M Ω /40 pF nominal at the instrument.

Ranges. 2.0 V (0.5 V/Div), 4.0 V (1.0 V/Div) and 8.0 V (2.0 V/div) at the probe tip.

Offset. From +5.0 V to -5.0 V in 1.0 V increments.

Bandwidth. 100 MHz

Clock Interval. Same as digital inputs, to 2 ns.

Maximum Input. ± 20 V continuous, ± 50 V transient (at the probe tip).

Accuracy. Gain error $\pm 5\%$ DC to 10 MHz
Offset error ± 10 mV $\pm 1.0\%$.

Resolution. 4 bits, 1 part in 16.

Coupling. DC only.

CLOCK

Internal. Selectable from 2 ns (500 MHz) to 50 ms (20 Hz) in a 1-2-5 sequence.

Channel to Channel Skew. < 1 ns.

External. Selectable positive or negative edge active, DC-130 MHz rate; clocking both edges DC-65 MHz rate.

Setup Time. < 2.5 ns.

Hold Time. 0.

TRIGGER

Three events control data recording: Arm, Enable and Trigger.

Arm. Selectable Manual, Auto (front panel switch), or via ECL or TTL level (user selected) rear panel BNC input (negative edge active). Autostop, Autostop within limits.

Enable. Selectable Auto, Manual or Combinational. When Combinational is selected, unit will seek a defined word. Once detected, unit will seek the Trigger.

Trigger. Selectable Auto, Manual, or Combinational, Analog, or External. When Combinational is selected, unit will seek a defined word. When Analog triggering is selected, triggering occurs on the changing of the MSB (either positive or negative). Once detected, the unit will execute the trigger delay selected, and stop recording. External triggering is done via a rear panel BNC, using a user selected TTL or ECL level (negative level active).

Qualifier. Trigger qualifier may be applied to Enable and/or Trigger.

Pattern Select. Enable and Trigger events may each be specified as a 9 bit word. The unit accepts binary (1, 0, X-don't care), as well as hexadecimal input. GO TRUE or GO FALSE conditions can be selected.

Delay. Trigger delay by clock intervals or trigger occurrences (or events) to 65,500 can be selected. Delay by clocks is always measured between trigger event and end of memory. When delaying by events, the nth + 1 event occupies memory location 1000.

Filter. When OFF, one occurrence of the trigger word is the trigger event. When ON, three occurrences of the trigger word are the trigger event.

Trigger Output. Rear panel BNC connector, TTL active low signal when unit detects trigger event. Synchronous with input data.

MEMORY

The K500-D contains a high speed record memory M, storage memory A, and reference memory B.

Size. M, A, and B are each 8 bits wide, 2000 words long.

Use. M accepts new data and automatically transfers it to A for display after the recording is completed.

Search. Via Status display, the unit accepts an 8 bit word for which it will search in memory A or B. All occurrences are marked by an asterisk. First and last occurrence, next and total number of occurrence, are tabulated on Time and Data displays.

Compare. Compare mode (A/B) prints # next to memory locations that do not meet comparison criterion between A and B memories.

Auto Stop. The unit Arms itself and acquires new data in A, which is compared with the contents of B. Whenever conditions are met, any further recording is prevented. This allows comparison between the contents of A and B. Conditions may be A=B or A≠B. Comparison may be made over entire 2000 words, or may be limited to the data that lies between the positions of Cursor and Reference, inclusive. Also, only those channels displayed participate in the comparison.

Display

Status, Timing, and data domain displays are via built-in raster scan CRT.

Status. Permits keyboard selection of recording and display parameters. Each parameter field (reverse video entry) is randomly addressable.

Timing. Eight channel format. Horizontal expansion X1, X10, X20, X50. Vertical expansion X2 via deleting channels. Cursor and Reference permit

direct time measurements when using internal clock. Binary readout of data at Cursor or Reference position. Trigger event, if in memory, is marked.

Data. Selectable binary, hexadecimal, octal, or SPCL (Special) display. Decoding depends on user selection of channel order. In Special Display, channel grouping permits decoding of data in binary, hexadecimal, octal, ASCII, or any combination.

Video Output. BNC rear panel connector provides composite video output, 1 V p-p into 75 Ω

MISCELLANEOUS

Size. 21.75 in. (473 cm) x 8.5 in. (72.25 cm) x 15.5 in. (240.25 cm).

Weight. 45 pounds (20.5 kg).

Power. 100/120 or 220/240 V RMS, +10%; 400 watts, 50 to 60 Hz.

Temperature Range. 0-50° C, operating.

Warranty. All Biomation products are warranted against defects in materials and workmanship for one year from date of delivery.

Accessories. Each unit is supplied with a set of input probes (10 digital inputs) with probe leads and grabbers, one analog probe, power cord, and one Operating Manual. Probes are 1.8m (6 ft.) long.



Figure 1.2 The Model K500-D Logic Analyzer with its high performance active probes.

OPERATING MANUAL
MODEL K500-D LOGIC ANALYZER
SECTION II
INSTALLATION

2.1 Introduction

This section contains information on unpacking, inspection, repacking, storage, and installation of the Model K500-D Logic Analyzer.

2.2 Unpacking and Inspection

Inspect instrument for shipping damage as soon as it is unpacked. Check for broken knobs and connectors; inspect cabinet and panel surfaces for dents and scratches. If the instrument is damaged in any way, or fails to operate properly, notify the carrier immediately. For assistance of any kind, including help with instruments under warranty, contact your local Gould Inc., Instruments Division, Biomation Operation representative or Gould Inc., Instruments Division, Biomation Operation in Santa Clara, California, USA.

2.3 Storage and Shipment

To protect valuable electronic equipment during storage or shipment, always use the best packaging methods available. Contract packaging companies in many cities can provide dependable custom packaging on short notice.

2.4 Power Connection

The K500-D may be used on a wide range of power line voltages and frequencies of 50 or 60 Hz minimal. The rear panel contains a fuse holder. Line voltage is selected by a switch on the rear panel.

Table 2.1 Line Voltage/Fuse Selection. Range shown is for 50-60 Hz line frequency.

Range ($\pm 10\%$)	Fuse (Amps) (Slow Blow 3AG)
100	5
120	5
220	2.5
240	2.5

2.5 Preparation for Use

The K500-D is entirely self contained with a built-in display and integral probe assemblies. All that is required is to connect the instrument to the line power and plug the probe assemblies into the front panel. When the K500-D is first turned on, it self-programs allowing you to connect your probes and collect data from your system. Once the data has been collected, you may easily modify the data collection or display to suit your requirements. This operation enhances the self-teaching ability of the instrument, so you can quickly learn how to operate it. For details, refer to Section III Operation.

2.6 Initial Warm-up

Although the K500-D is a solid-state instrument, a brief warm-up period of approximately 10 minutes is required for the internal circuitry to reach thermal stability.

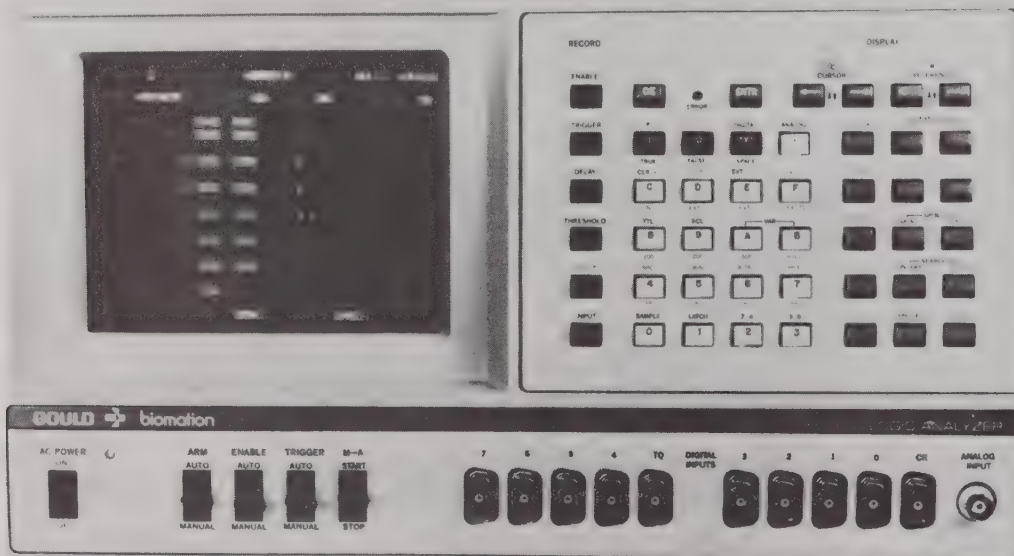


Figure 2.1 Front panel of K500-D.

OPERATING MANUAL
MODEL K500-D LOGIC ANALYZER
SECTION III
OPERATION

3.1 Introduction

For first time users of logic analyzers, Section 3.2 discusses the basics of logic analysis for those readers. Others, who are familiar with logic analyzers, can use this section for a discussion of actual keystrokes and hands-on usage. Those readers familiar with the K100-D will find the prompter book and examples in Section 3.2 sufficient to operate the K500-D. Paragraphs 3.1.1 through 3.1.21 are an outline of three types of recordings, and can serve as a review for use by readers already familiar with the K500-D.

Digital Recording Example

3.1.1 Two types of digital recording can be made, synchronous and asynchronous. Both types will be discussed.

3.1.1.1 Making an asynchronous recording.

First, a recording of a 4 bit counter will be made, probing the MSB on channel 0 and the LSB on channel 3. After the probes are connected, the status parameters are selected. The order of parameter selection does not matter, the clock rate, delay, trigger word, threshold, or enable word can be selected in any order.

3.1.1.2 To select a digital recording,

Press:

STATUS

,

"X"



Figure 3.1.1 The word DIGITAL appears in the upper left corner of the CRT.

3.1.2 Selecting a Clock Rate

If the user does not know which clock rate to use, he can select a mid-range and then increase or decrease it after an initial recording. To select a 10 μ s clock rate, press:

CLOCK , 10 , μ SEC , ENTR .

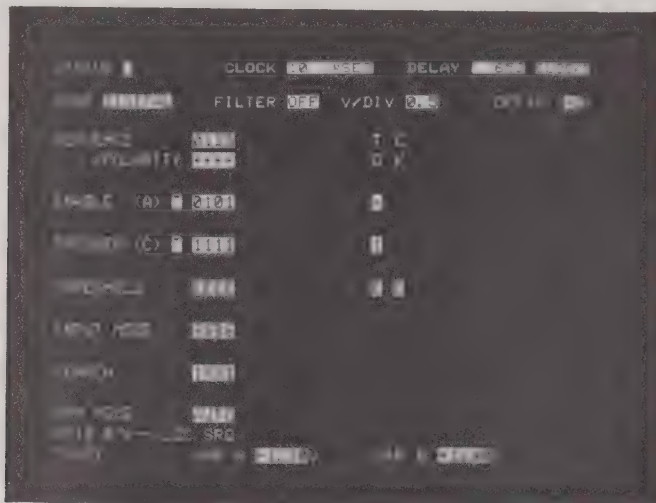


Figure 3.1.2 The CRT displays the clock rate selected.

3.1.3 Selecting a Delay

The delay parameter moves the viewing window. The delay is specified in clocks or events and it is referenced from the trigger event. The delay defines the end of the recording. A delay of 600 clocks means the recording ends 600 clock pulses after the trigger word. To select a delay of 652 clocks, press:

DELAY , 6 , 5 , 2 ,
C , and ENTR .

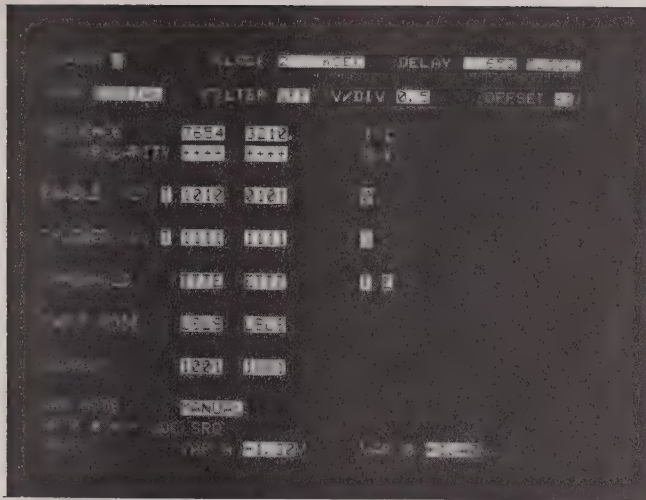


Figure 3.1.3 The CRT displays the selected delay.

3.1.4 Selecting Sequence

When performing a recording of a 4 bit counter with the MSB on channel 0 and the LSB on channel 3, the best sequence to select is 0, 1, 2, 3 and eliminating the rest. To select that sequence, press:

SEQ , 0 , 1 , 2 ,
3 , then "X" ,

until the other channels are blanked out, and then press ENTR.

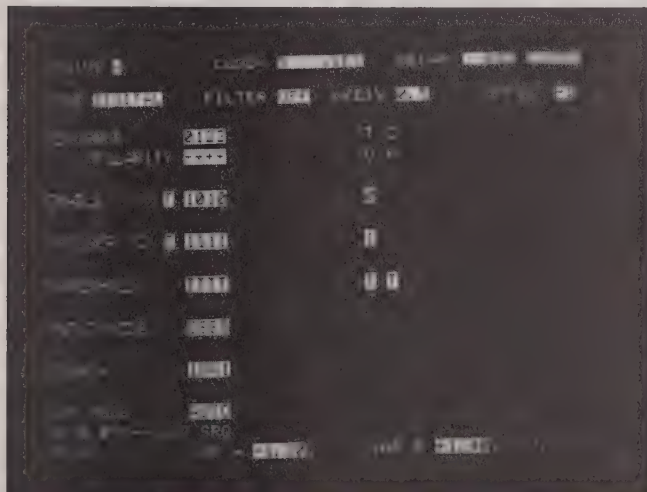


Figure 3.1.4 The CRT displays the selected sequence.

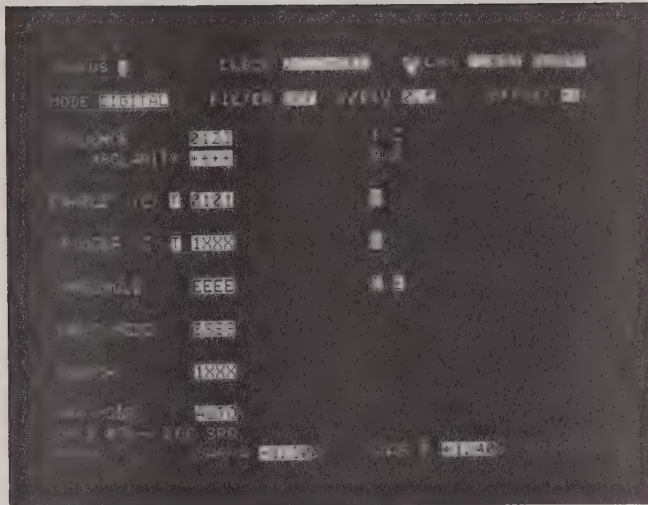


Figure 3.1.6 A "T" appears next to the word ENABLE on the CRT.

3.1.7 Selecting Thresholds

Since only 4 channels are being recorded, it is necessary to select only 4 thresholds. To select TTL thresholds (+1.4 V), press:

THRESHOLD , TTL ,

until the field is filled on the CRT, and then ENTR.

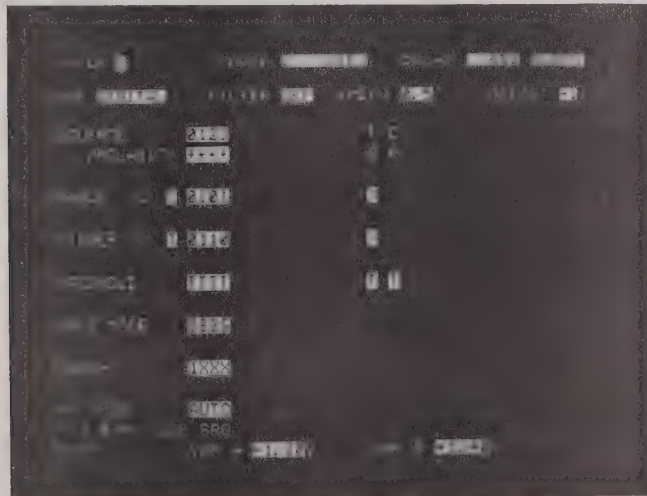


Figure 3.1.7 T's appear in the threshold field on the CRT.

3.1.8 Selecting Input Modes

Either sample or latch can be selected on a per channel basis. The latch mode catches glitches between clock edges, whereas the sample mode only captures clock edge occurrences. To select all sample press:

INPUT , SAMPLE

until field is filled on the CRT, and then ENTR ,
OR

INPUT , SAMPLE , 3-0 , and ENTR .



Figure 3.1.8 S's appear in the Input Mode Field of the CRT.

3.1.9 Selecting a Combinational Trigger Word

The K500-D offers several types of triggering capabilities. For this example, the appearance of a specific word in the data stream will trigger the unit. First, to assure that a digital (as opposed to an analog) trigger will be selected, press:

TRIGGER , DIGITAL .

To enter 6_{HEX} as the trigger word, press either:

TRIGGER , 6 , and ENTR ,

OR

TRIGGER , "0" , "1" , "1" ,
"0" , and ENTR .

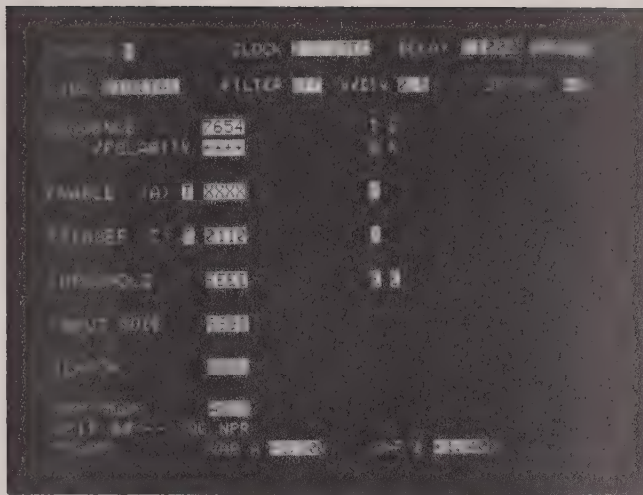


Figure 3.1.9 The selected trigger word appears in the trigger field.

3.1.10 ARMing

Now that the clock, delay, sequence, polarity, input mode, thresholds, enable word, and trigger word have been selected, the CRT should look like Figure 3.1.9.

Press the ARM button down to manually arm the unit. A recording has been made.

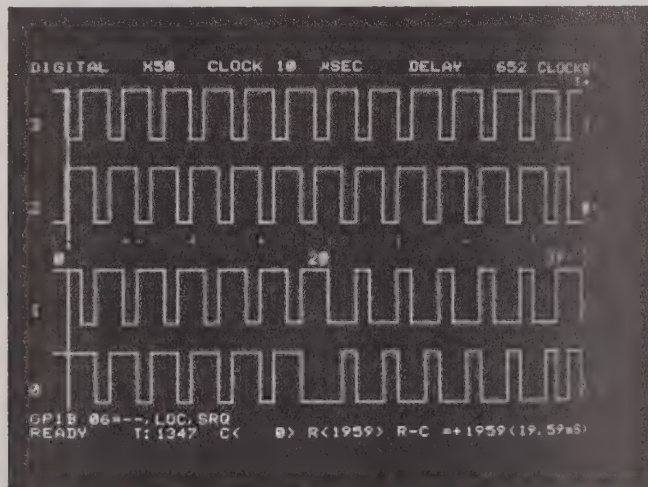


Figure 3.1.10 Note that the 10 μ s clock rate, which corresponds to 100 KHz, is slower than the counter's clock.

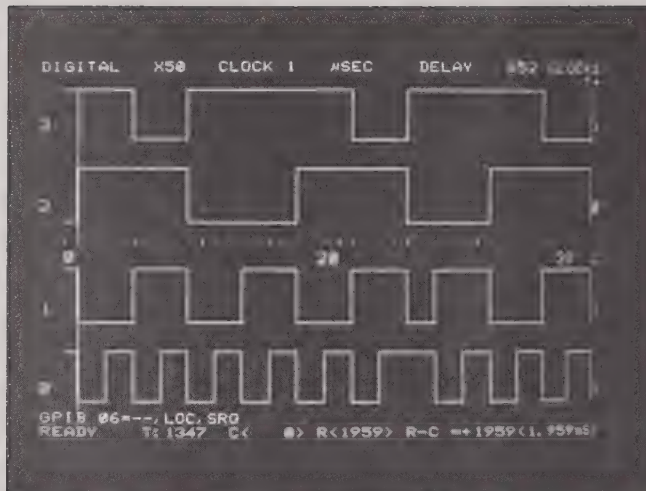


Figure 3.1.11 By changing the clock rate to 1 μ s (1 MHz), the timing display looks like a 4 bit counter in this second recording.

3.1.11 Making a Synchronous Recording

The second type of digital recording is synchronous with the system's clock. Again, the parameters may be selected in any order. To select a digital recording, press:

STATUS and "X".

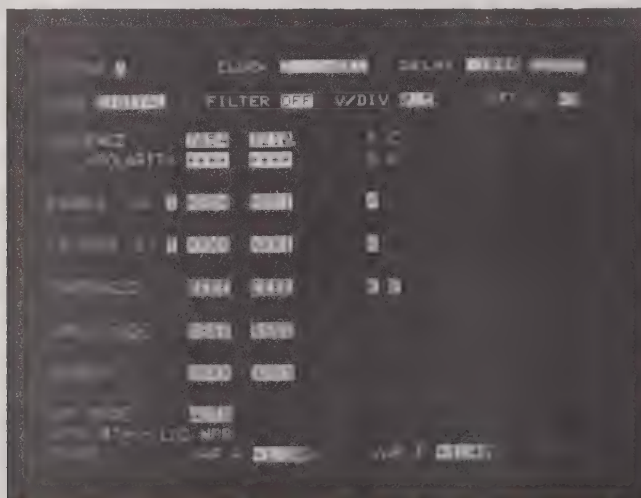


Figure 3.1.12 The word DIGITAL appears on the upper left corner of the CRT.

3.1.12 Selecting an External Clock

The user should know on which of the clock edges the data is valid. Either the falling edge , or the rising edge , or both edges may be selected. To select a falling edge, press:

CLOCK , EXT , and ENTR .

If the selected edge is wrong (data not valid), then try

EXT , ENTR

and make a new recording.

DIGITAL	HEX	CLOCK EXT1	DELAY	652 CLOCKS
000	3	020 7	040 3	060 F
001	4	021 8	041 C	061 0
002	5	022 9	042 D	062 1
003	6	023 A	043 E	063 2
004	7	024 B	044 F	064 3
005	8	025 C	045 0	065 4
006	9	026 D	046 1	066 5
007	A	027 E	047 2	067 6
008	B	028 F	048 3	068 7
009	C	029 0	049 4	069 8
010	D	030 1	050 5	070 9
011	E	031 2	051 6	071 A
012	F	032 3	052 7	072 B
013	0	033 4	053 8	073 C
014	1	034 5	054 9	074 D
015	2	035 6	055 A	075 E
016	3	036 7	056 1	076 F
017	4	037 8	057 C	077 0
018	5	038 9	058 D	078 1
019	6	039 A	059 E	079 2

GP18 07---, LOC, SRC
READY T: 1347 C< 0> R(1959) R-C => 1959

Figure 3.1.13 EXT appears in the clock parameter field on the CRT.

3.1.13 Selecting a Delay

The delay parameter moves the viewing window. The delay is specified in clocks or events and is referenced from the trigger event. The delay defines the end of the recording.

A delay of 600 clocks means the recording ends 600 clock pulses after the trigger word. To select a delay of 652 clocks, press:

DELAY , 6 , 5 , 2 ,
C , and ENTR .

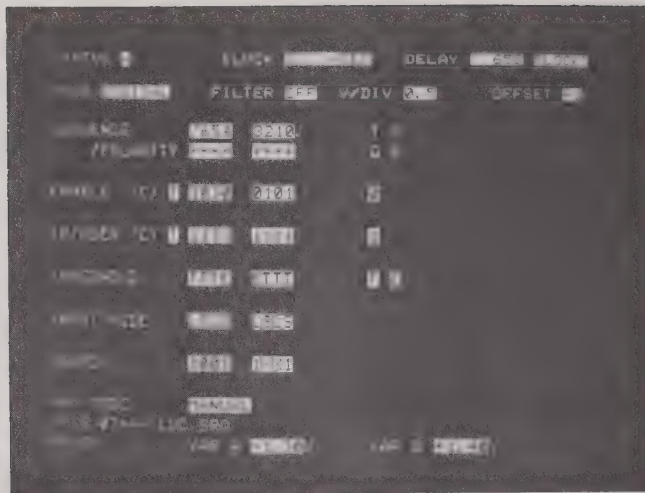


Figure 3.1.14 The CRT displays the selected delay.

3.1.14 Selecting Sequence

Since a recording of a 4 bit counter with the MSB on a channel 0 and the LSB on channel 3 is being made, the best sequence to select is 0, 1, 2, 3 and eliminating the rest. To select that sequence, press:

SEQ	,	0	,	1	,	2	,
3	,	"X"					

until the other channels are blanked out, then

ENTR	.
------	---



Figure 3.1.15 The CRT displays the selected sequence.

3.1.15 Selecting Polarity

A system may use positive or negative polarity. When TTL is recorded, positive logic means above +1.4 V = 1 and, below +1.4 = 0. When negative logic is recorded, above +1.4 V = 0 and below +1.4 = 1. To select positive logic press:

SEQ , "1"

until all characters have "+" under them, and then

ENTR .

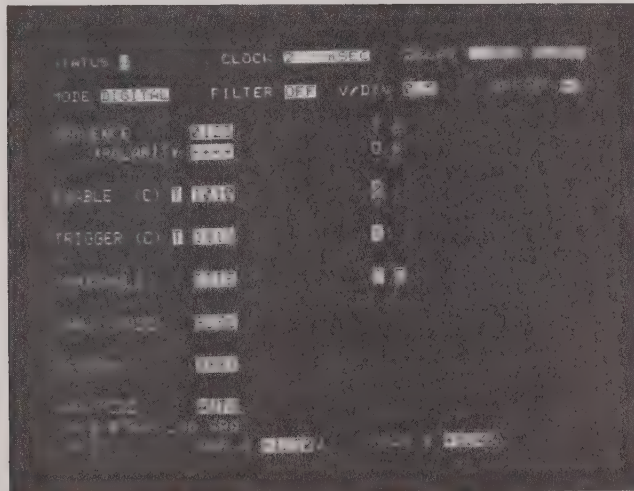


Figure 3.1.16 The CRT displays selected polarity in the sequence field.

3.1.16 Selecting an Enable Word

Several types of enabling are available. For this example, the unit will enable when a 5_{HEX} is present. This can be entered two ways. Press:

ENABLE , 5 , ENTR ,

OR

ENABLE , "0" , "1" , "0" ,
"1" , and ENTR .

The CRT will display the selected Enable word. A true enable must be false then become true; a false enable must be true and then become false. To select true enable, press:

ENABLE , (CURSOR) ← , "1" ,
and ENTR .

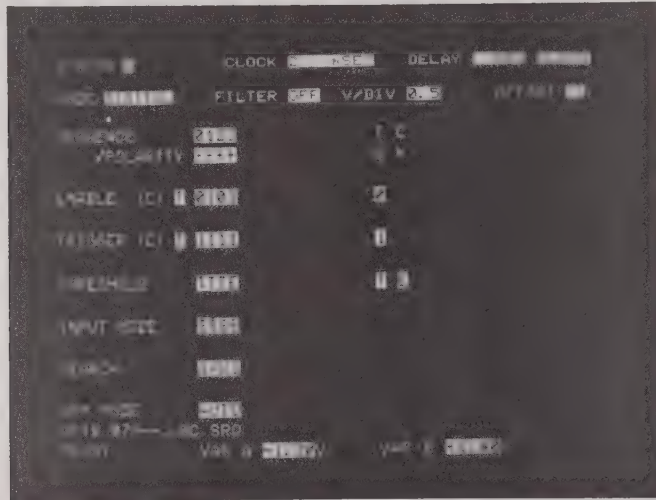


Figure 3.1.17 A "T" appears next to the word ENABLE on the CRT.

3.1.17 Selecting Thresholds

Since only 4 channels are being recorded, it is necessary to select only 4 thresholds. To select TTL thresholds (+1.4 V), press:

THRESHOLD , m
until the field is filled with "T"s) then
ENTR .

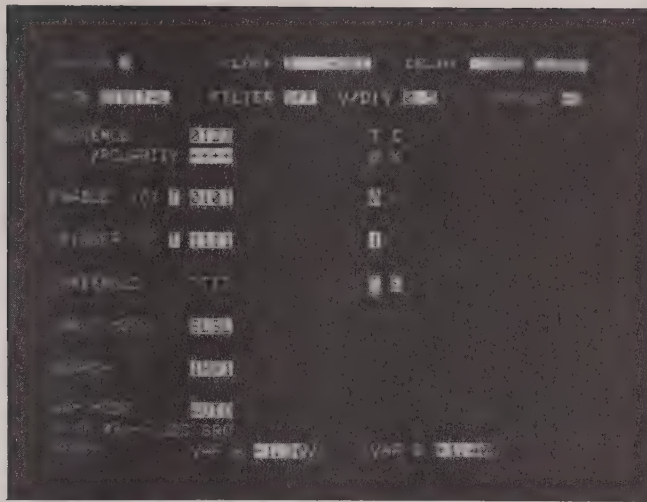


Figure 3.1.18 T's will appear in the threshold field on the CRT.

3.1.18 Selecting Input Modes

Either sample or latch can be selected on a per channel basis. The latch mode catches glitches between clock edges, whereas the sample mode only captures clock edge occurrences. To select the sample mode, press either:

,

(until the field is filled on the CRT) and then

;

OR

, , , and .

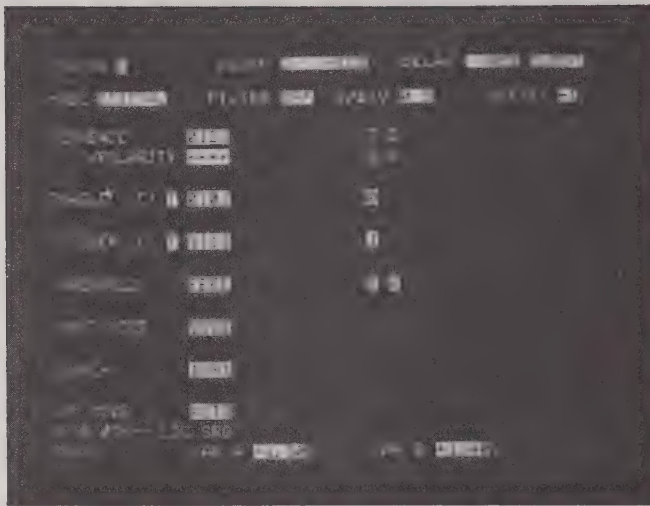


Figure 3.1.19 S's will appear in the input mode field of the CRT.

3.1.19 Selecting a Combinational Trigger Word

The K500-D offers several types of triggering capabilities. For this example, the appearance of a specific word in the data stream will trigger the unit. First, to assure that a digital (as opposed to an analog) trigger will be selected, press:

TRIGGER and "X" .

To enter 6_{HEX} as the trigger word, press:

TRIGGER , 6 , ENTR ,

OR

TRIGGER , "0" , "1" , "1" ,

"0" , and ENTR .

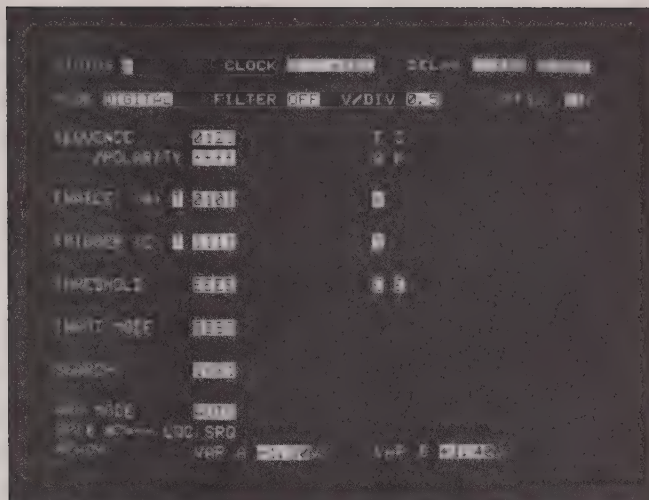


Figure 3.1.20 The K500-D will trigger on a 6_{HEX}.

3.1.20 ARming

Now that the clock, delay, sequence, polarity, input mode, thresholds, enable word, and trigger word have been selected, the CRT should look like Figure 3.1.21.

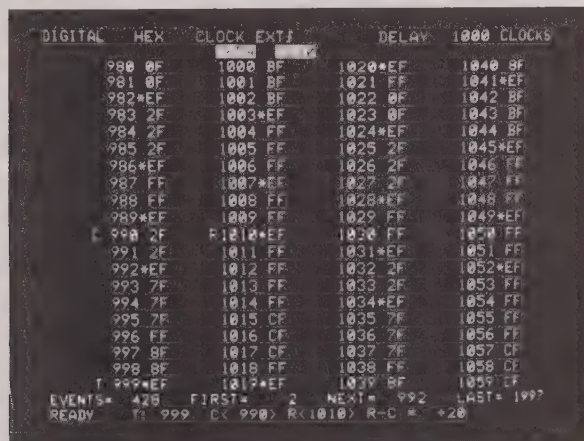


Figure 3.1.21 Data display of a synchronous recording.

Press the ARM button down to manually arm the unit. A recording has been made, when RDY appears in the lower left corner of the CRT.

3.1.21 Making an Analog Recording

An analog recording can be made, by pressing

ANALOG ;

the word ANALOG will appear near the upper left corner of the CRT. If digital event triggering is desired, the instructions relating to making a

digital recording apply with the exception of this first keystroke in lieu of the

"X"

keystroke.

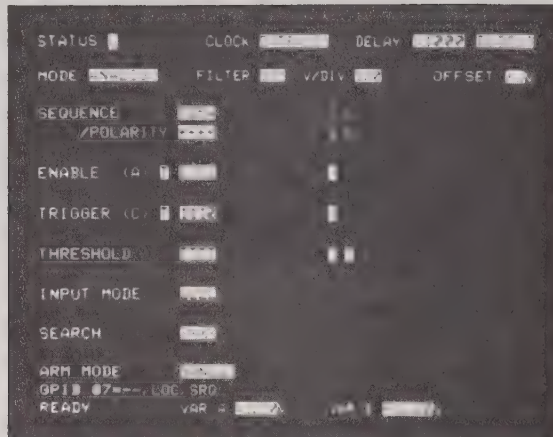


Figure 3.1.22 CRT in Analog Mode

To trigger on an analog event, press:

STATUS , TRIGGER , ANALOG , and ENTR .

The word ANALOG will appear in the trigger field.

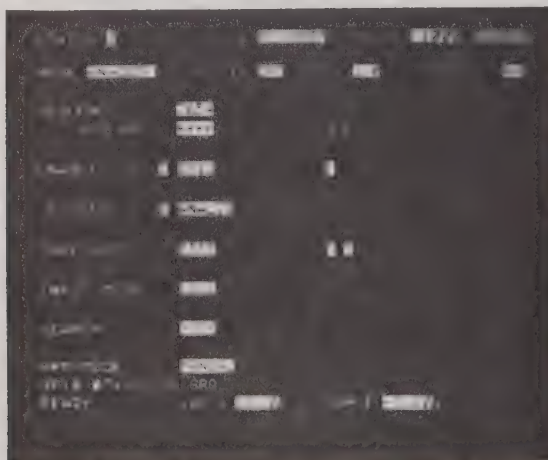


Figure 3.1.23 CRT with Analog Triggering Selected

Analog triggering occurs when the MSB becomes 1 (true trigger) or 0 (false trigger). The MSB changes when the waveform crosses mid-range. The MSB goes to 1 when the slope is positive going and to 0 when the slope is negative going. To select true triggering, press:

TRIGGER , (CURSOR) ← , "1"

and ENTR .

To select false triggering, press

TRIGGER , (CURSOR) ← , "0" ,

and ENTR .

The scale (volts/div) and offset are selected by similar methods. Each time V/DIV or OFFSET is pressed, a new value will appear on the CRT with status displayed. Values will reappear. The keys can be thought of as one direction circular switches. After the scale and offset have been selected, an analog recording will be made on channels 0 to 3. Channels 4 to 7 are available simultaneously for digital recordings. V/DIV and offset can be selected on the time domain display. By pressing

V/DIV

OR

OFFSET ,

the display can be entered momentarily.

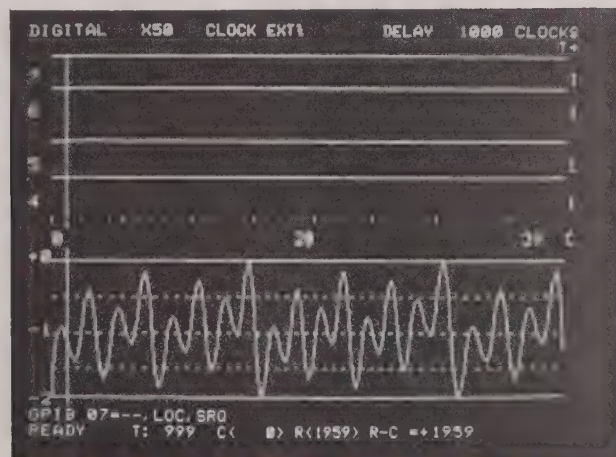


Figure 3.1.24 The results of an analog recording displayed in time domain.

The ENTR key can be used as indicated previously. However, opening a new parameter field infers ENTR of the previously opened field. Therefore,

DELAY , 8 , 9 , C ,

ENTR , CLOCK

is the same as pressing

DELAY , 8 , 9 , C ,

CLOCK .

3.2 Basics of Logic Analysis

Some readers may be first-time users of a logic analyzer. This portion of the operation section deals with the basics of logic analysis. Readers with a high familiarity with logic analyzers, particularly the Biomation K100-D, may wish to proceed directly to Section 3.2.

3.2.1 Purpose of Logic Analyzers

The predominant circuitry in use during the past two decades has changed from analog circuits characterized by discrete components to digital circuits using microprocessor-based systems. Viewing of analog and digital signals was originally possible only with an oscilloscope. While the oscilloscope worked well on repetitive analog signals, it did an inadequate job of showing the non-repetitive signals and multipoint occurrences that characterize digital signals. The oscilloscope yields more information than is required about analog signals and almost no information about the data stream except its presence. Information such as waveshape, rise time, and amplitude are not very important to the digital service technician or manufacturing test technician, and are of minimal importance to the digital design engineer or software designer (people who are interested in viewing several test points over a period of time and knowing if a point is a logic "1" or "0"). The time relationships of several digital waveforms is important to them, as is the data sequence. The logic analyzer was invented to view the data stream. The data stream is what is occurring at a set of electrical points simultaneously. The occurrences are often changing.

Table 3.2.1 An 8-bit Data Stream.

Test Point	Time							
A	0	0	1	1	1	0	1	1
B	1	1	0	1	0	1	1	1
C	1	1	0	0	0	0	0	0
D	0	1	0	0	1	1	1	1
E	1	1	0	0	1	1	1	0
F	0	0	1	0	1	0	0	1
G	1	0	1	1	0	0	1	0
H	1	0	1	1	0	0	1	0

The stream can be thought of as flowing through the logic analyzer. When a particular set of "1"s and "0"s flows through the logic analyzer, it freezes the stream in time so it can be viewed (see Table 3.2.1). To accomplish the data freeze properly, several factors must interact:

- 1) A threshold voltage definition that changes an analog (real waveform) to a digital waveform (1 or 0). Over threshold = 1, under = 0 (or the reverse).
- 2) A clocking arrangement that defines how often the logic analyzer looks at the data stream. Two types are possible: a (synchronous) data related clock from the circuit being tested, or a clock (asynchronous) in the logic analyzer pulsing at a much higher rate than data changes.
- 3) A trigger event definition so that the data stream is frozen at exactly the right moment. These factors were taken into consideration in the development of the early logic analyzers. Later generations became more sophisticated in order to concentrate on more complex trigger events, formatting, and displaying data.

The basic electronic parameters of a logic analyzer remain the same over the years. They are the:

- 1) Number of channels (how wide a stream you can look at).

- 2) Memory depth (how long in time a section of the data stream can be frozen).
- 3) Speed (how short a period between looks at the data stream is possible).

Convenience features have been added to reduce the time spent organizing the data, and to allow more time for analysis. These features include:

- 1) Built-in CRT to display data and select recording parameters.
- 2) Computer interfaces to output data and input parameter selections (and output data to printers).
- 3) Interactive keyboards and associated ergonomic advances.

3.2.2 Functional Description of a Logic Analyzer

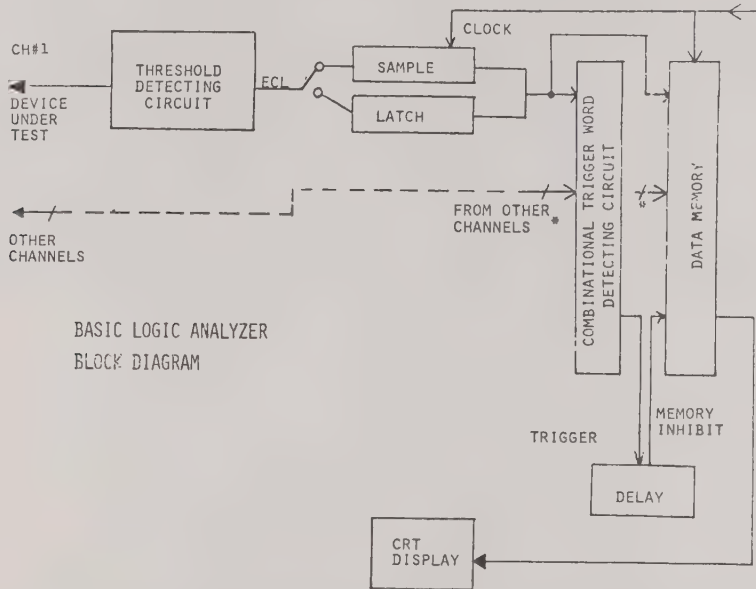


Figure 3.2.1 In order to better understand what is in the frozen data stream, a typical logic analyzer in block form is described here.

3.2.2.1 Probes

The purpose of the probe is to provide a means of connecting an electrical point, on the device under test (DUT), to the threshold sensing circuit of the logic analyzer. The probe is designed so as not to create anomalies that alter the performance of the DUT, and faithfully transfer the signal without altering it. In lowspeed logic analyzers (below 50 MHz clocking), the distance between the threshold sensing circuit and the point on the DUT could be quite large without causing anomalies. However, in higher speed logic analyzers the threshold sensing circuits must be close to the point on the DUT.

3.2.3 Threshold Detection (Glitch Concept)

The purpose of the threshold detecting circuit is to change an analog waveform into a digital waveform by comparing the analog waveform to a user defined threshold voltage. When the analog waveform is greater than the threshold (or reference) voltage, the output is a logic "1"; when the input is less than the threshold voltage, the output is a logic "0". A glitch is defined as a pulse of very short duration. The pulse can be either positive or negative going. The glitch capture specification of a logic analyzer is often very important to the user. To a large extent, this specification is determined by how short a glitch will cause the threshold

detecting circuitry to respond. Typically, a certain amount of energy must be input to the threshold detector to make it respond. That energy is the area under the curve of the glitch's waveform. For example, the glitch specification for the K500-D is 2 ns with a voltage overdrive of 250 mV with respect to the threshold voltage.

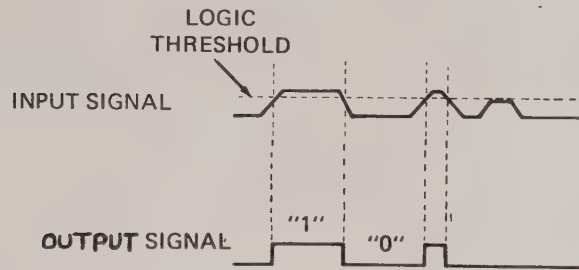


Figure 3.2.2 In the threshold detecting circuit, the input signal is compared to a selected logic threshold.

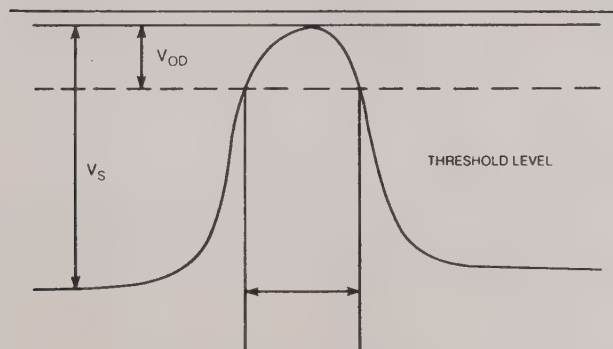


Figure 3.2.3 The VOD represents the area under the curve that contains the energy required to make the threshold circuit respond with an output pulse.

3.2.4 Sample/Latch Input Modes

The output of the threshold detector, a crisp one or zero, goes to either a user selectable sample or latch circuit. Each circuit will cause different data to be recorded. When the sample circuit (mode) is selected, the output of the threshold detector is viewed only at the active clock edge. When the latch mode is selected, occurrences between active clock edges are detected.

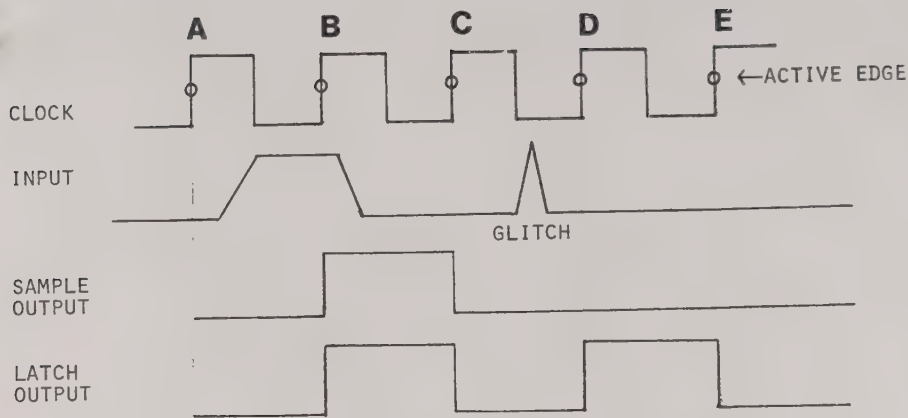


Figure 3.2.4 A through E are the active edges of the clock. When the sample circuit views the input on edge B, it sees a "1" until the next active clock edge (C). When clock edge D occurs, the sample circuit sees a "0" until the next active edge (E). Using the latch circuit, at active edge D, the circuit views what happened between edges D and C, which was a positive-going glitch, therefore the output of the latch circuit between edges D and E is a high.

The important concepts are:

- 1) Sample circuits view occurrences at the clock edge.
- 2) Latch circuits view occurrences between clock edges.
- 3) If no glitch occurred, the outputs of sample and latch circuits are the same.
- 4) Outputs lag behind inputs by one clock period, and change only at active clock edges.

3.2.5 Enable/Trigger

The data stream is typically long, containing far more information than is needed to analyze what is going on. For most applications, only a small portion of the stream must be observed. The trigger of a logic analyzer is analogous to the shutter of a camera. It "clicks" when exactly the right thing comes into view. Similarly, the logic analyzer waits for a particular event to happen before it freezes the data stream, just as the camera freezes the action. The enable and trigger events are part of the total event that freezes the data stream. A delay after the enable and trigger events may be the total event that freezes the data stream. The enable event is an occurrence of a digital word in the data stream. The data word is selected by defining it in terms of ones (1), zeros (0) or don't cares (X).

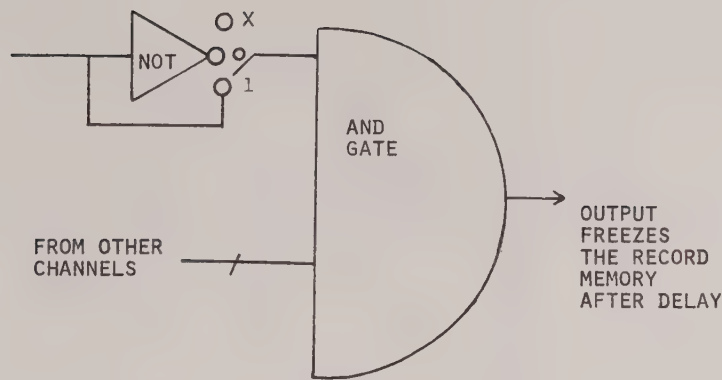


Figure 3.2.5 The combinational trigger word detector outputs a freeze signal to freeze the data stream.

The enable event must occur before the logic analyzer starts to look for the trigger event. The trigger event can be a digital word or an analog event. Many logic analyzers allow for external, or non-recorded, signals to be their arm, trigger, or enable event. The important concepts are:

- 1) The triggering event can be defined as a combination of several events happening in sequence.
- 2) The triggering event defines the portion of the data stream that is frozen or captured in sequence, including: non-recorded signals, combinational words in the data stream, delays, and analog signals.

The trend in lower speed logic analyzers is to offer very complex triggering configurations to allow the recording of a very precise portion of the data. A high speed logic analyzer has a less complex triggering method. Because it has a longer memory, it freezes a larger portion of the stream, thus making the need to capture a very precise portion of the stream less critical.

3.2.6 Delay

Once the trigger word is found, the data stream is frozen. Sometimes, what is captured is not exactly what is wanted. Freezing can be delayed to capture a different portion of the stream. There are two ways a delay period can be selected. Delay by clocks means that the data stream is frozen a certain number of clocks after the trigger event. Delay by events means that the trigger event must occur a certain number of times before the data stream is frozen. For the trigger event to be recognized, it must be false, then true each time.

DELAY BY CLOCKS

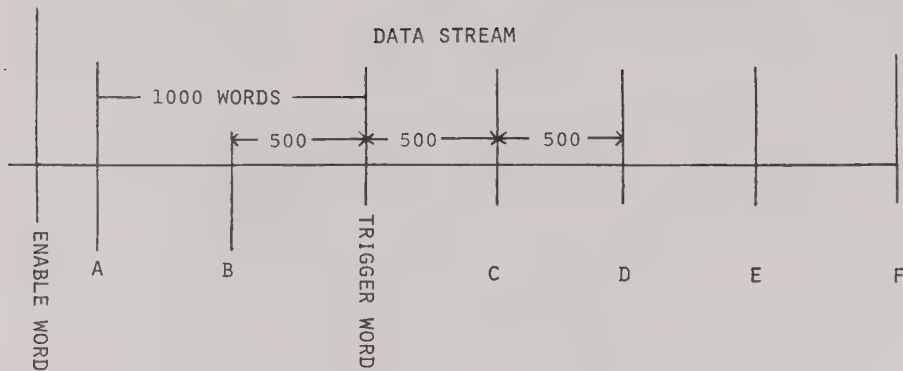


Figure 3.2.6 If the logic analyzer has a 1000 word memory:

Delay = 0 clocks
Captures data from A to the trigger word

Delay = 500 clocks
Captures data from B to C

Delay = 1000 clocks
Captures data from the trigger word to D

Delay = 1500 clocks
Captures data from C to E

Delay = 2000 clocks
Captures data from D to F

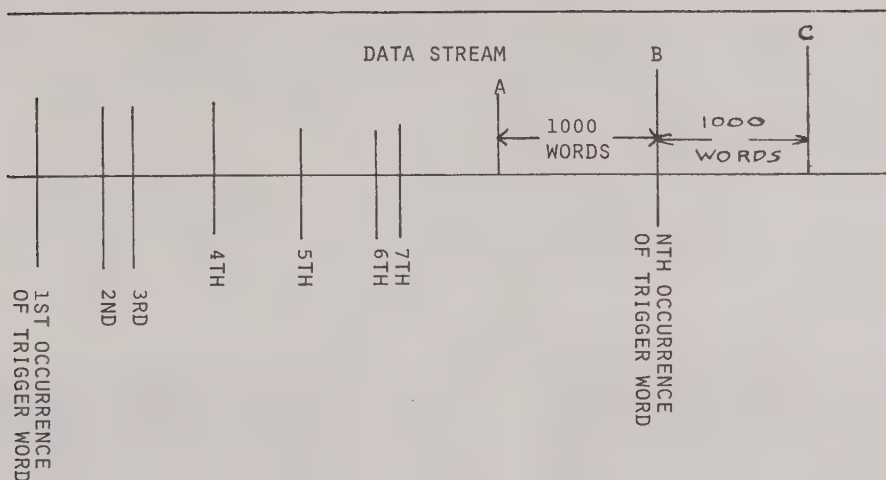


Figure 3.2.7 When triggering is delayed by N events, the Nth occurrence falls in the center of the captured data. The data between A and C is captured.

By slowly moving the window created by the delay, and making several recordings, the particular portion of the data to be seen can be isolated.

3.2.7 Clocking

The clock signal is an input to both the latch and sample circuits. The memory uses the same clock signal to advance the data stream through the memory. When logic analyzers were first invented, two types existed. The difference between them was the clocking method used:

- 1) Data Domain logic analyzers used a clock derived from the DUT; the data was valid on the clock edge and occurred synchronously with the active clock edge. This is called synchronous clocking.
- 2) Time Domain logic analyzers evolved from waveform digitizers. A clock rate much higher than that of the waveform being recorded is used. The source of the clock is a crystal oscillator. The clock rates are user selectable. The clocking is asynchronous since it has no relationship to the DUT's clock. The purpose of asynchronous clocking is to view the real-time relationship between various pulses.

The modern logic analyzer clocks both synchronously and asynchronously at the user's discretion. Often complex synchronous clocking is possible using several clocks that are logically joined to create a composite clock that is a function of several input clocks. High asynchronous clock rates are now available, with the K500-D offering the highest at 500 MHz. This means timing relationships can be resolved between events with 2 ns resolution.

The important concepts are:

- 1) Synchronous clocking uses an externally supplied clock(s), and is used to look at valid data on the active clock edge.
- 2) Asynchronous clocking uses an internal clock, and is used to measure the timing relationship of various digital waveforms.

3.2.8 Data Manipulation

The greatest advances in logic analysis have come in the area of data manipulation. Data is usually displayed on a CRT in two basic forms; data domain codes and timing diagrams.

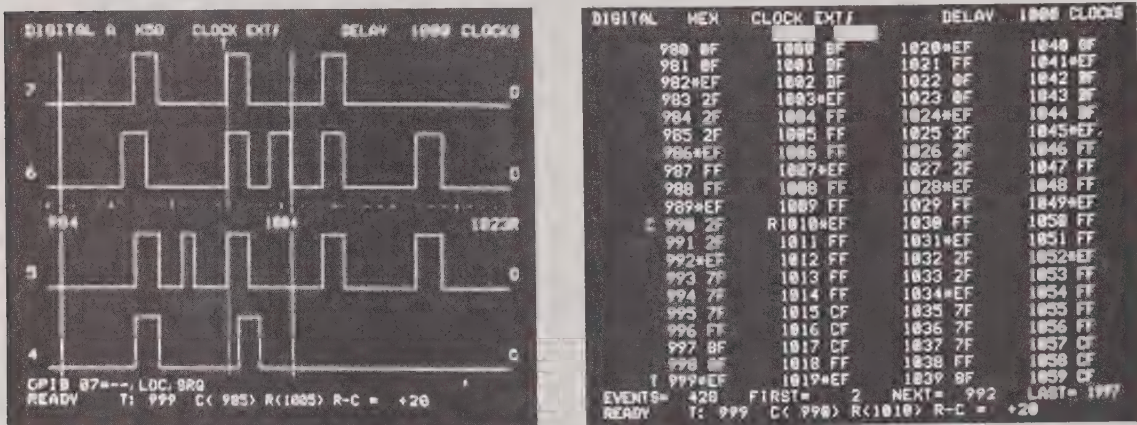


Figure 3.2.8 Data display (right) and Timing display (left) provide two different perspectives on the same information.

Data displays are formattable so that data can be studied in an easy to interpret format. For example: binary, hex, octal, and ASCII (7 bit teletype alphabet code). A feature such as Search helps locate the occurrences in the frozen data stream, while Compare allows comparison of one data recording to an earlier recording. Timing displays are expandable in order to magnify a portion of the data stream and bring it into proper focus. Display sequence may be changed so as to put two channels next to each other to examine their relative timing relationship.

The important concepts are:

- 1) Data displays are software tools that allow the data to be viewed in an easy to understand format. Typically, a program execution is viewed one step at a time to determine if execution is as it was planned to be.
- 2) Timing displays are hardware tools that help find real-time related anomalies in the circuit. Timing relationships between channels are revealed.

3.3 Operating the K500-D

3.3.1 Introduction

The Model K500-D Logic Analyzer uses a keyboard entry system and interactive display for control of recording and display parameters. The arrangement of this control subsystem was designed for quick and easy learning of the effect of various keys, and the proper use of the features available in the instrument. It does this through the use of the Status display mode, shown in Figure 3.3.1. When the K500-D is first powered up, it goes through a self-diagnostic test wherein it checks its keyboard and memories. A detailed explanation of the test and its error indications is found in Section VI, Maintenance. If the instrument indicates any errors in the power up self test, the source of the error may be diagnosed down to the IC package level using the diagnostic routine. The unit also loads part of its own program into display memory. This allows the operator to practice specifying display parameters without having to record data.

3.3.2 Parameter Fields

Each reverse video (bright box) entry in the Status mode denotes a parameter field. Any one of these parameter fields may be randomly addressed and modified. Use the column of black keys on the right edge of the display to access any parameter field. In addition to the column of black keys, the blue keys labeled SEQ (Sequence) and SEARCH are used in the same fashion to access those respective parameter fields. There are also four momentary toggle switches on the lower front panel that access various parameter fields. The operation of the K500-D can be thought of as four types of operation:

- 1) Prior to recording, parameters for recording are selected by the user.
- 2) During recording, the K500-D displays information related to the recording in progress.
- 3) After the recording, the data is manipulated by the user.
- 4) The GPIB interface allows parameter selection, display of recording information, and manipulation of data under computer control.

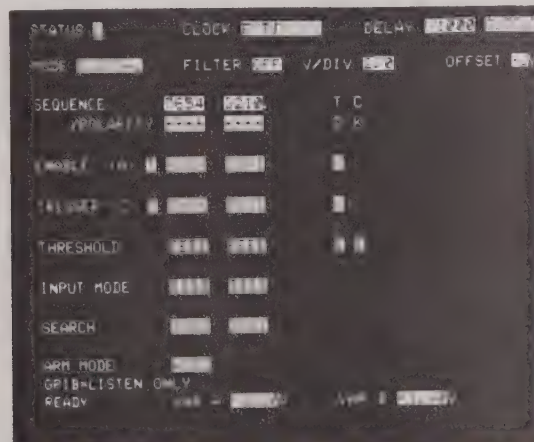


Figure 3.3.1 A random menu scheme allows the user to select parameter fields in any convenient order. Changing parameters as needed is straight forward.

Status parameters are displayed on the CRT, letting the user know if the correct selection was entered. On the left side of the keyboard are the names of the six most commonly used (prior to recording) parameter fields. The keys to the right of those parameter fields enter the desired parameter into the field. Moving further right, the three last columns contain display types; status, data, or timing. Subsets of the three display types are selected by the analog and digital keys.

3.3.3 Hardware Considerations

Before using the K500-D, several items should be considered. DIP switches inside the unit should be set, the power cable should be inserted, and probes attached to the circuit under test and power turned on. When the power is turned on, the K500-D performs a self-diagnostic. See the Maintenance Section of the manual if a failure of the self-diagnostic occurs. When the test is passed, the K500-D is ready to make a recording.

3.3.3.1 Internal DIP Switches

A set of 5 DIP switches is located on the data display board of the K500-D chassis. The top cover must be removed to access the DIP switch. The purpose of the switches is to preselect default (power-up) parameters.

Switch #1 1=clock is INT (2 ns)
0=clock is EXT

Switch #2 1=threshold is ECL
0=threshold is TTL

Switch #3 Autoflush
0=Disabled
1=Enabled

Switch #4 Trigger hold off
0=Disabled
1=Enabled

Switch #5 GPIB TON Format
0=No TON Format
1=TON Format

Auto flush enabled will fill the A memory with zeros before arming. Trigger hold off enabled will fill the memory with 2000 bytes of data before looking for the enable event. The GPIB TON format will output characters to a GPIB printer that duplicates the CRT display in both status and data display modes.

REMOTE ARMING

The unit can be remotely armed via a rear panel BNC connector. A positive going transition of the input clocks flip-flop 5C which the microprocessor polls at a 60 Hz rate. The microprocessor then arms the instrument so that a recording may occur.

The user may program internal jumpers so that the input threshold of this signal may be LSTTL or 10 K ECL. Minimum pulse width is 10 ns. To use TTL compatible signals, jumpers must be connected on the Record Control PCB (0950-0003) from E8 to E9 and from E11 to E12. To use ECL compatible signals connect E7 to E8 and E10 to E11.

TRIGGER OUTPUT

The unit outputs a signal each time the trigger event occurs. A TTL compatible active low signal is output when the instrument is in its triggered state. To output a TTL compatible signal on the rear panel BNC, connect jumpers on the Record Control PCB as follows: E1 to E2, and E4 to E5. To output ECL signals, connect E2 to E3 and E5 to E6.

3.3.3.2 Probes

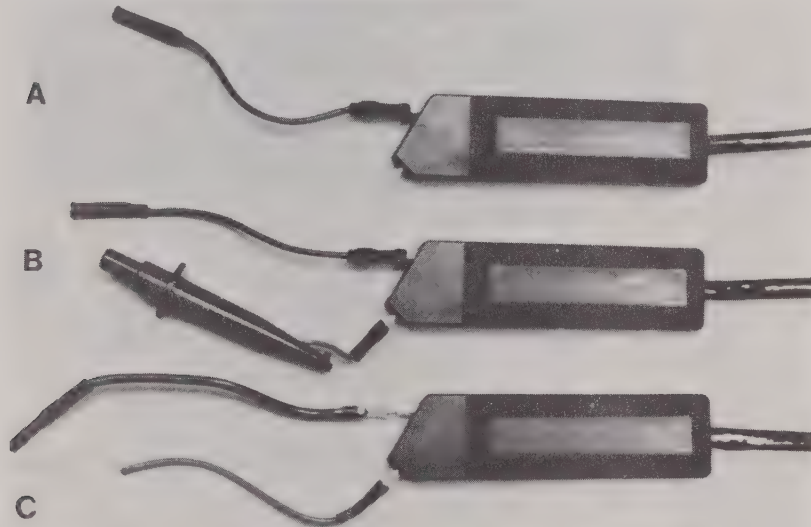


Figure 3.3.2 Probing test points is accomplished by using spikes (A), grabbers (B), or flying leads (C).

When probing for glitches as narrow as 2 ns, it is essential to place the threshold detecting circuit as close to the test point as possible in order to prevent reflections. Reflections can cause the threshold detecting circuit to detect the same glitch twice. In order to keep the distance short, special probing devices were designed:

- 1) Grabbers to hug component legs.
- 2) Flying leads to slip over posts on DIP clips or in the circuit.
- 3) Spikes to probe hard to attach to points like traces on boards.

3.3.3.3 Self Test

In addition to running a diagnostic test during power-up, the K500-D has a built in self test feature that can isolate problems to the PC board level.

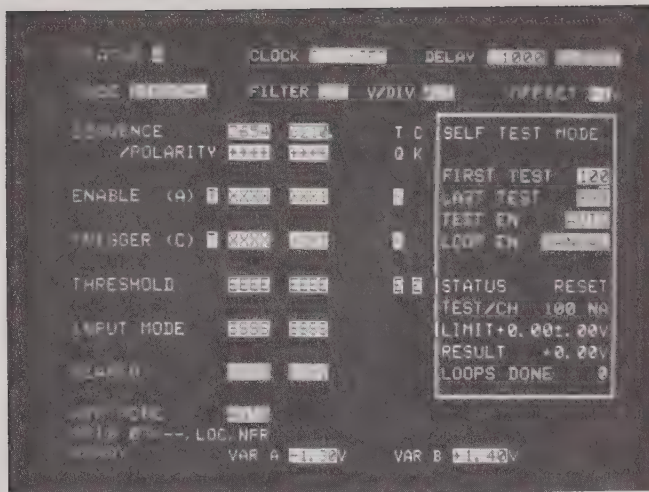


Figure 3.3.3 Press the SELF-TEST key to obtain the self test display. The display will indicate which tests were failed, if any. The Maintenance Section of the manual explains the test information and operation.

3.3.4 Setting Up to Record

After the unit is powered up and passes the self-diagnostic test, a recording can be made.

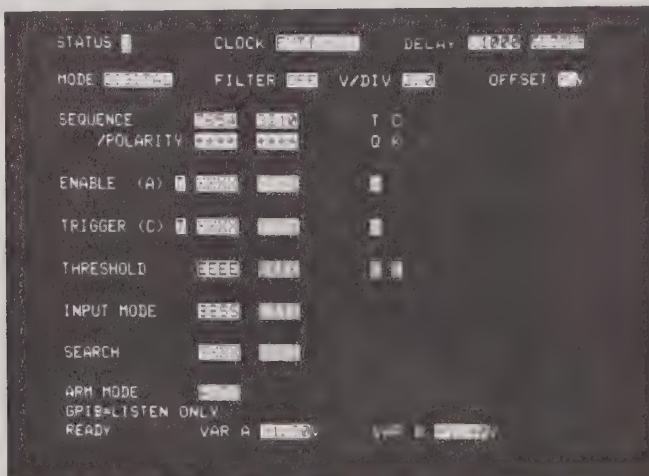


Figure 3.3.4 The K500-D powers up with the default parameters as shown. The default parameters are probably not the ones needed to make an appropriate recording.

First, the user should decide whether an 8-bit digital recording or an analog recording with 4 digital signals will be made. Press DIGITAL for an 8-bit digital recording or ANALOG for an analog recording with 4 digital bits. After the ANALOG/DIGITAL selection is completed, the user can elect to change the clock rate, delay, sequence, polarity, enable event, trigger event, trigger filter, input mode, or the threshold settings as required. After those parameters are entered, the K500-D is ready to be armed and make a recording.

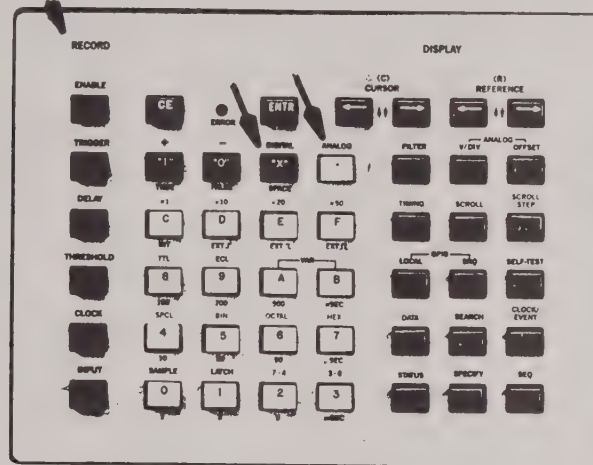


Figure 3.3.5 The DIGITAL and ANALOG keys select the recording of 8 digital bits (DIGITAL) or 4 digital signals and waveform (ANALOG). The six record keys open the parameter field prior to selection of the parameter.

3.3.5 STATUS W, A, B

STATUS W is the Status display mode shown on the CRT when any parameter field has been addressed or changed. This denotes that a subsequent measurement with different parameters from those used for the last measurement is to be made. Once a parameter field has been changed, and a new measurement (or recording) is made, STATUS W becomes STATUS A.

STATUS A indicates the parameter fields that were used to record and display information that is stored in Memory A. STATUS A display cannot be changed before a measurement has been made.

STATUS B refers to the data stored in Memory B. This is done by loading new data into A and transferring it to B, or loading B via the GPIB.

STATUS A or B displays may be called up on the CRT while in the Status mode.

STATUS W may be called up by opening any one of the parameter fields (any black button on the left column) and pressing the blue key ENTR.

3.3.6 Recording Sequence

Several things must happen before a recording is completed and stored in memory.

- 1) If the trigger hold off feature is enabled, the unit must see 2000 clocks before the Arm is accepted.
- 2) The Arm is accepted, the unit looks for the enable event.
- 3) The unit is enabled and is looking for the trigger event.
- 4) The unit is triggered and is waiting for the specified delay period.
- 5) The delay is over, a recording is in memory.

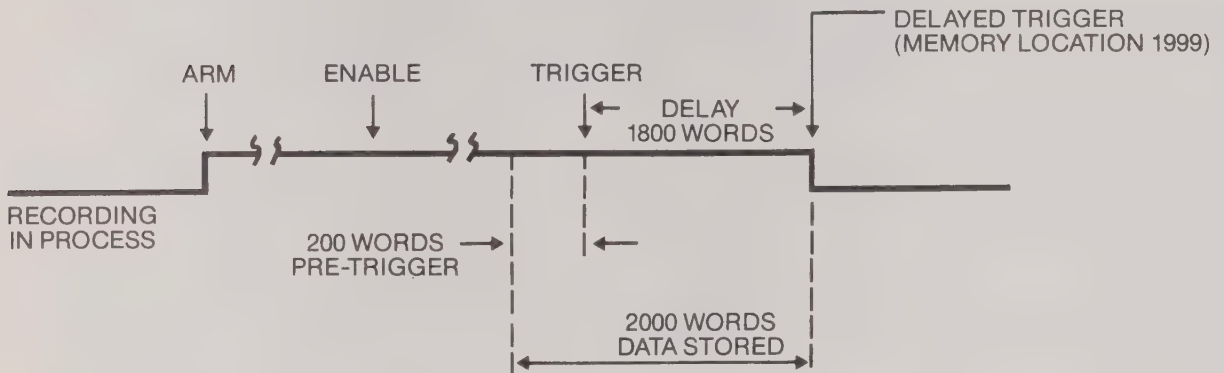


Figure 3.3.6 Three events, in sequence, are required to complete a recording. The trigger actually controls the memory contents. The enable is a qualifying event to allow the instrument to seek the trigger. The arm event not only begins the recording, but also acts as a precursor of the enable event. The combination of enable and trigger event allow "nested" triggering. In this example, the trigger delay is 1800 clocks.

3.3.7 Arm

Four different ways to arm the K500-D make it a very flexible feature.

Either Auto Arm or Manual Arm may be selected with the ARM button. In Manual Arm mode, the instrument makes a measurement after it has been manually armed with the ARM button (down). It completely executes the measurement and returns to a ready for arm state, as denoted by READY on the CRT (lower left corner). If the ARM button is pushed up, the instrument then automatically arms itself upon completion of each measurement. Because of the internal housekeeping, the maximum rate at which the instrument can arm itself, and detect Enable and Trigger Events, is on the order of 10 times per second.

Usually the Manual Arm mode is used to directly control the measurement process. The Auto Arm mode is generally used to observe continuous updates of the operation in a circuit. To avoid possible errors in a recording, always return the instrument to Manual Arm, RDY state, before changing any record parameters. If the instrument is in some other state, this can be accomplished by pressing the ARM switch down a second time.

The third arming method is Autostop. The unit re-arms automatically until the condition is such that it will not re-arm. The condition is $A=B$ or $A \neq B$ where A is the memory of the last recording and B is the reference memory.

B is usually a known good synchronous recording (transferred from the A memory or loaded via the GPIB), A is a recording of a questionable circuit. To function properly, synchronous recordings should be used.

The A#B comparison can be for the entire 2000 word memory or for a limited section of memory determined by the cursor positions and channels displayed. The comparison is made between cursor locations, including the cursor positions, in memory. This feature is of extreme value for ATE applications and diagnostics.

The fourth arming method is via a rear panel BNC connector. When a positive-going pulse appears on that connector, from an external source, the unit arms. The signal may be ECL or TTL as required.

External arm can be the third level of tested triggering if a 10TC pod is used. The 10TC triggering pod logically ANDs up to 10 inputs to output a user selectable ECL or TTL pulse when a combinational trigger word is present for 10 ns. (Ask your local Biomatron Representative for a demonstration.)

PROMPTER

Manual ARM: - Down - ARM button must be pressed down for every recording

AUTO ARM: - Up - Unit will re-ARM after every recording

AUTOSTOP ARM: - Compares memories. A=B then stop. Can be A=B, then compares only the memory between the cursors. To enter, press AUTOSTOP A#B, then

AUTO ARM when arming.

EXTERNAL ARM: - Pulse - ECL or TTL on rear panel BNC connector.

3.3.8 Enable

The enable parameter field allows definition of an 8 bit word, plus a qualifier bit. Once the unit is armed, it must find the enable word before it can look for the trigger word.

The default condition for the enable word is automatic, as denoted by the A in parentheses. This means that the K500-D bypasses the enable event and immediately looks for the trigger. Press the ENABLE paddle switch up for auto enable.

There are two other conditions for the enable event. They are manual (M) and combinational (C). These other two conditions are also shown within the parentheses. To enter a manual enable, press down the ENABLE switch and the M will appear in the parentheses. Note that the unit will not seek a defined enable word, but will always expect to see a manual enable, initiated by the ENABLE key.

The act of defining an enable word changes the letter in parentheses to a C, denoting combinational enable. This is done by opening the enable parameter field with the ENABLE key. You can then key in, using either the three binary keys (black keys labeled "1", "0", "X"), or key in a hexadecimal word. When you key in a hex word, the unit decodes each hex character (16 white keys) and places four binary bits in the parameter field for each hex character entered.

If a combinational enable is defined for a subsequent measurement, the enable word selected may not be found by the instrument once it is armed. In that case, press down on the ENABLE key to manually enable (overriding combinational enable) the unit and complete the measurement. For the next measurement, the unit will be in the manual enable mode. Press the enable key again. To select a combinational enable without disturbing the enable word previously entered, the enable parameter field must be reopened, and the enable word already there must be entered. In other words, press

ENABLE

, then

ENTR

.

To the left of the enable word parameter field is a reverse video T. This denotes true or false enable. When true enable is selected, the instrument will seek the enable word. When it finds a condition where the input signals match the pattern defined, it will have detected the enable event. TG? will now appear on the lower left corner of the CRT. Prior to finding the enable word, EN? appeared.

It can also select combinational false enable. In this mode, the unit will seek the defined enable event. It will continue to monitor this event until any one of the bits changes states. At this point, it will recognize the enable event.

To select enable true or false, open the enable parameter field by pressing the ENABLE key. The underline cursor will locate itself to the entry for the leftmost channel; in this case, Channel 8. Then press the cursor or reference left arrow key to move the underline cursor beneath the T in the field. Then use black key FALSE to change the T to F. To select T, again position underline cursor as before, and press TRUE.

TRIGGER QUALIFIER

The qualifier TQ at the right end of the enable and trigger parameter fields can be independently set for both enable and trigger events. When you have entered the LSB for the enable word, in this case Channel 0, the underline cursor will step to the TQ position. The state for TQ can be selected by using the "1", "0", or "X" key.

3.3.9 Trigger/Filter Selection

MANUAL TRIGGER

Triggering is very similar to enabling. The K500-D has five definable trigger events. Three of them are identical to enabling. Manual triggering ignores the combinational trigger event specified and initiates the delay period. For each recording the manual TRIGGER switch must be pressed down to manually trigger the unit. An (M) will appear in the trigger field, and the only ways to trigger the unit is to press the TRIGGER switch down, or select auto trigger, or combinational trigger.

AUTO TRIGGER

Auto trigger selection is made by pressing the TRIGGER paddle switch up. An (A) will appear in the trigger parameter field and the unit will never look for a trigger word. The unit will trigger immediately after it is enabled.

COMBINATIONAL TRIGGER

Combinational triggering is the most beneficial selection. Similar to combinational enabling, the unit again looks for an 8 bit word plus 1 qualifier (TQ) bit combination in order to trigger. The 9 bit combinational trigger word is selected either in binary or hex. To specify a

trigger word, press TRIGGER to open the parameter field; to specify the word in binary, use the black keys labeled 1, 0, or X (don't care); to specify the word in hex, use the white keys labeled 0 to F. Each key corresponds to 4 binary bits. Select the state for TQ using the black keys again. The position of the decimal point controls what is actually displayed on the CRT. Thus, if you enter 765.43210, the K500-D will display only channels 7, 6, and 5, but trigger from all 8 inputs. If you enter 7654, where channels 3 through 0 are deleted using the SPACE key, the K500-D will display, and trigger from, only channels 7 through 4. As an example, press the blue key SEQ and, using the cursor or reference position keys, place the underline one position to the right of Channel 4. Key in a period and press ENTR. The ERROR LED will come on. Note that the underline cursor now positions itself to the second entry of the period. Press SPACE (X) and then ENTR. The status display will be refreshed and show only four channels.

Press the blue key labeled TIMING then press the white key labeled X50. The display should now look like Figure 3.3.7

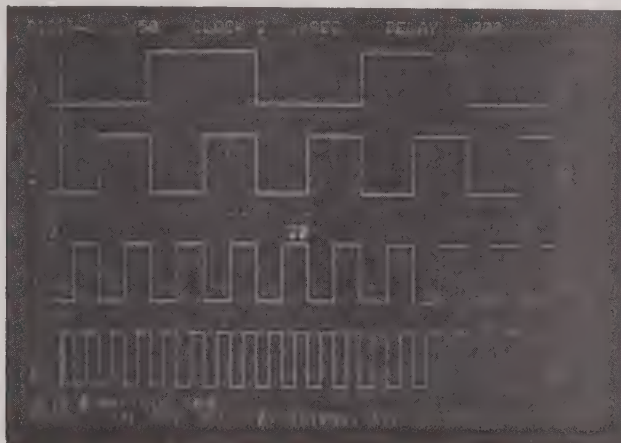


Figure 3.3.7 Just four channels are displayed, giving an automatic vertical expansion of 2X. Horizontal expansion is also selected.

Notice that only four channels are now displayed, 0 through 3. Also notice that a vertical expansion by a factor of 2 has occurred. This vertical expansion is automatic when four or less channels are displayed.

Also, since a horizontal expansion factor of 50 was selected, the data displayed is now only 40 memory cells and gives a very easily examined timing format.

FILTER SELECTION

Noise may trigger the K500-D in the latch mode, where a word need only be present for 2 ns. To prevent that from happening, press the filter key. The word FILTER will appear on the right side of the CRT. When on, the filter will require the combinational trigger word to be sampled for three consecutive clock periods, when off, only one clock period.

TRUE/FALSE TRIGGER

The combinational trigger word can be specified true or false. True defined as changing from false to true. False defined as changing from true to false. To specify true or false, open the trigger field (unnecessary if already open) and move the C cursor under the existing T or F, press the 1, or 0 key, to change the true value as required. Note the cursor is a bar under the character about to be entered. It can be used to correct erroneous selections.

ANALOG TRIGGERING

Analog triggering is selected by opening the trigger field (press TRIGGER key) and then pressing the ANALOG key. The word analog will appear in the trigger parameter field. Triggering occurs when the MSB changes logic state. By selecting true analog triggering, the unit triggers when the MSB of the 4 bit ADC becomes a "1" (at 1/2 of the input voltage range), when false analog triggering is selected, the same MSB must become a "0" to cause triggering. Both of these trigger events occur when the waveform crosses the offset voltage selected by the user.

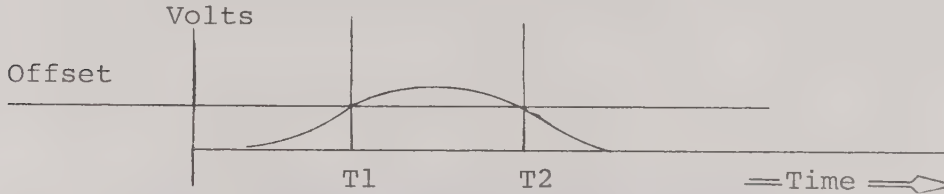


Figure 3.3.8 If true analog trigger was selected, the unit triggers at T1; if False Trigger, it triggers at T2.

The analog triggering capability can be used to record a digital or digital plus analog data stream. In conjunction with a combinational enable word, the analog trigger feature becomes a very powerful tool for viewing analog/digital related anomalies such as A/D and D/A conversion times.

NOTE: When analog recording or triggering is selected, the K500-D can be combinationally enabled or triggered on bits 4 through 7 only since the 0 through 3 bits are used by the analog channel.

External triggering is available via a rear panel BNC connector. A positive-going pulse will trigger the unit and override the triggering method unless otherwise front panel specified. The user selects an ECL or TTL input via an internal DIP switch.

PROMPTER: Select an Enable of A4 and a trigger of XXX1 XXXX binary.
To select the Enable, press:

ENABLE	A	4	ENTR
ENABLE	1	0	1
0	0	0	1
0	ENTR		

OR

To select the trigger, press:

TRIGGER	"X"	"X"	"X"
"1"	"X"	"X"	"X"
"X"	ENTR		

NOTE: Individual bits may be entered using the black keys ("0", "1", "X") or 4 characters at a time in hex using white keys (0 through F).

3.3.10 Delay

K500-D users can select to delay the end of recording by up to 65,000 clocks or events. Delay is with respect to the first occurrence of the trigger event. Delay by clocks is selected by opening the delay parameter field by pressing the DELAY key, then the CLK X1 key to its right. The number of delay clocks is selected with the white numeral keys (0 to 9). To select delay by events, press the delay key, then the EVT X20 key to the right. Select the number of events the same as was done for clocks. When delay by events is selected, the recording will end after the number of trigger events delay selected plus 1. The last, or N + 1, occurrence of the trigger word will be at memory 999 in the center of the memory.

PROMPTER:

Select Delay = 200 events

Press:

DELAY	2	0	0	EVT x 20	recording
					1000 1000
1st Event			100th Occurrence 201st Occurrence		

3.3.11 Clock Field

The K500-D makes available two types of clocking; synchronous clocking using a clock derived from the system under test for examining program execution, and asynchronous clocking using a crystal oscillator inside the unit, for timing relationship analysis. Internal (asynchronous) clock rates are selected by clock period, i.e. 2 ns selection corresponds to 500 MHz. To select an asynchronous clock rate, press the CLOCK key to open the clock parameter field, then select the required rate using the white keys 0 to B. The clock associated markings are in red.

PROMPTER:

Select a 20 μ s clock rate.

Press:

CLOCK

,

5

,

7

,

ENTR

.

The K500-D can accept system clock at rates between DC and 130 MHz or 65 MHz on both edges. The minimum clock pulse width shall be 2 ns before the active clock edge. Likewise, the hold time requires that the data must stay settled for 0 ns after the active clock edge. Clock thresholds are selectable.

PROMPTER:

Select an External, rising edge active

Press:

CLOCK

,

EXT

,

ENTR

3.3.12 Sequence Field

This parameter field operates on the display of recorded information and does not affect the recording.

The sequence portion of the parameter field allows you to rearrange all 8 channels in any desired order. No channel may be entered more than once. If any attempt is made to enter a channel more than once, the ERROR LED will come on, and the underline cursor will move to the second entry of that channel. This allows for easy recovery from an entry error. The second

entry of that particular channel can be deleted by pressing the SPACE key and then ENTR. If there are several multiple entries, the underline cursor will point them out for removal. The sequence field permits the data to be formatted in a manner that makes the most sense to the analysis approach being used. In addition to single keystroke selection of hex, octal, or binary displays when in the data domain, several data decodings can be combined.

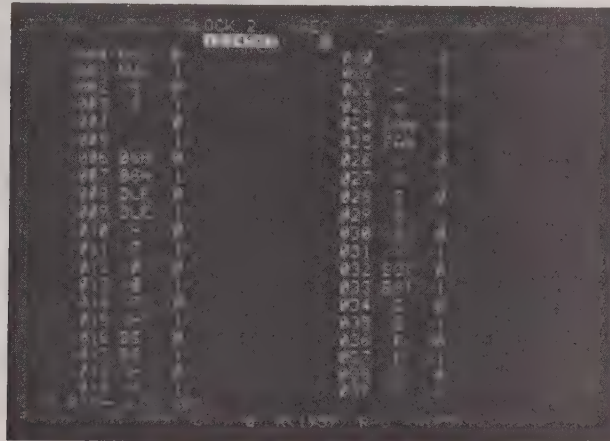


Figure 3.3.9 Data display with the 7 MSBs in ASCII and the 0 bit in binary. The SPCL key was pressed.

The SPCL key causes the unit to observe the channel grouping selected as shown in Figure 3.3.9. Here, the channels have been grouped, with spaces between groupings, to tell the unit how to decode the data.

The full ASCII character set is decoded, including upper and lower case (denoted by brackets) letters, numbers, and all control characters. Those entries in the ASCII string that are not decoded (displayed as seven binary bits) are the characters that are not universally defined.

In the special data domain, the channels can be arranged in any desired order, and in any combination of groups.

The sequence field can be used to display less than the total number of channels. Placement of the decimal point anywhere in the sequence row will delete from display all channels to the right of the period. The double entry rule also applies to the decimal point.

3.3.12.1 TRUNCATED DISPLAY

The position of the decimal point controls what is actually displayed on the CRT. Enter: 765.43210 and the K500-D will display only channels 7, 6, and 5, but trigger from all 8 inputs. Enter 7654, where channels 3 through 0 are deleted using the SPACE key, and the K500-D will display, and trigger from, only channels 7 through 4.

As an example, press the blue SEQ key and, using the cursor or reference position keys, place the underline one position to the right of Channel 4. Key in a decimal point and press ENTR. The ERROR LED will come on. Note that the underline cursor now positions itself to the second entry of the decimal point. Press SPACE (X) and then

ENTR. The status display will be refreshed and show only four channels.

Press the blue key labeled TIMING. Also press the white key labeled X50. Your display should now look like Figure 3.3.10

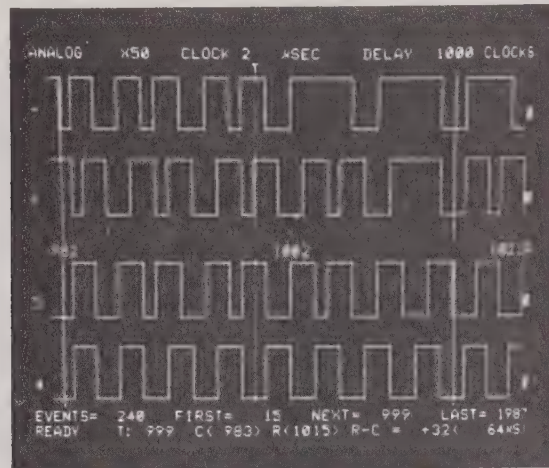


Figure 3.3.10 Just four channels are displayed, giving an automatic vertical expansion of 4. Times 50 horizontal expansion is also selected.

Notice that only four channels are now displayed. Also notice that a vertical expansion by a factor of 2 has occurred. This vertical expansion is automatic when four or fewer channels are displayed.

Since a horizontal expansion factor of 50 was selected, the data displayed is now only 40 memory cells wide, and displayed in an easy-to-examine timing format.

PROMPTER: Sequence to trigger and record from channels 7,6,5,4,3, in that order.

Press:

SEQ	7	6	5	4
-----	---	---	---	---

3	X
---	---

 until all remaining channels are erased.

Press:

ENTR

Final display:

7	6	5	4	3
---	---	---	---	---

Sequence to record on channel 5, but trigger on 5, 7, and 6.
Press:

SEQ	5	.	7	6
-----	---	---	---	---

X

 until all remaining channels are erased.

Press:

ENTR

Final Display:

5	7	6
---	---	---

3.3.13 Polarity Selection

The polarity portion of the parameter field allows selection for display, on a per channel basis, of either positive or negative convention polarity. This allows the data domain format to be rearranged to allow for any inverted signals in the system. Plus or minus signs may be entered by using the black keys labeled + and -. The polarity must be selected prior to recording. Polarity entered after a recording will pertain to the next recording.

PROMPTER: Select negative polarity for channels 7 to 4 and positive for channels 3 to 0. Assumed: the sequence 7 0, unknown polarity.

Press:

SEQ	,	"0"	,	"0"	,	"0"	,	"0"	,
"1"	,	"1"	,	"1"	,	"1"	,	ENTR	

Note that clock and trigger qualifier polarity are selected similarly.

3.3.14 Threshold Field

This parameter field allows independent selection of a threshold reference level for each channel. One of four different threshold voltages can be assigned to any one channel. The black THRESHOLD key opens this field. Notice on the keyboard that the row of four white keys to the right of the THRESHOLD key are those keys used to assign the thresholds. Either a preset TTL (+1.4 V), preset ECL (-1.3 v), and two variable thresholds, A and B, can be selected through the keyboard.

All eight input channels, plus the qualifier input and the external clock may be independently assigned from this list of four different threshold levels.

To specify the variables A and B, open these parameter fields by pressing the blue SPECIFY key, and then the white VAR A or VAR B key. Enter a threshold voltage from the keyboard using keys 0 through 9, and enter voltage polarity with the black + and - keys, subject to the following two restrictions: Voltage entered must lie between -6.35 V and +6.30 V. Voltage can only be specified in 0.05 V increments. Any entry condition that violates the above rules will cause the ERROR LED to come on.

PROMPTER:

Select a -3.05 V threshold for all channels.

Assumption - default (power-up) sequence in the STATUS mode.

Press:

SPECIFY	,	A	,	0	,	3	,	.
0	,	5	,	ENTR	,			

VAR A = -3.05 V should be displayed on the bottom of the CRT.

Press:

INPUT	,	A	,	A	,	A	,	
A	,	A	,	A	,	A	,	A
ENTR	,							

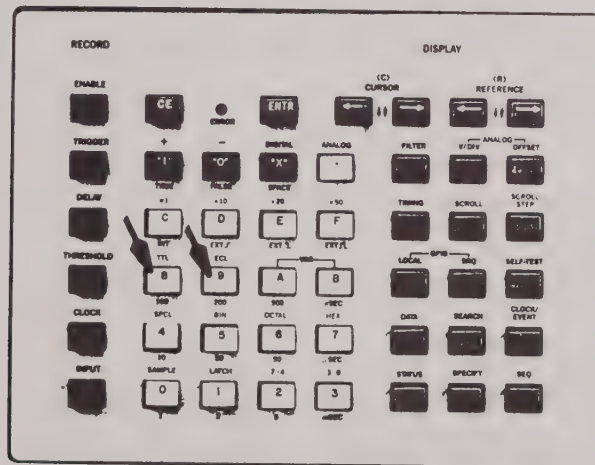


Figure 3.3.11 The keys associated with selecting a voltage threshold are highlighted.

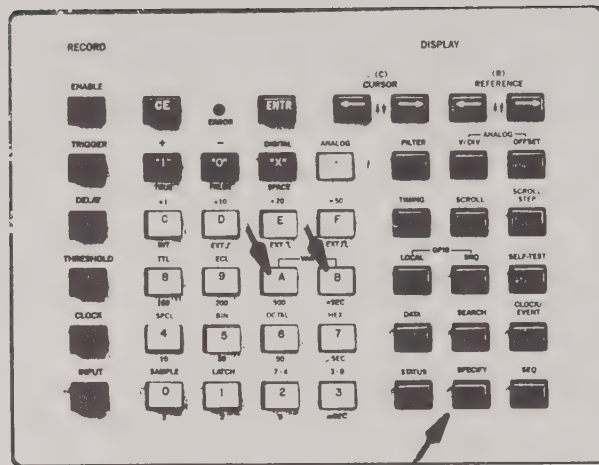


Figure 3.3.12 The keys associated with specifying values for Variable thresholds A and B are highlighted.

3.3.15 Input Mode Field

Sample or latch input modes can be independently selected for each channel. This parameter field is addressed via the black INPUT key.

Notice, as with the threshold parameter field, the four keys associated with the input mode are in the same row as the INPUT key.

There are two ways of programming the inputs. First is through the parameter field by assigning sample and latch input modes on a per channel basis by pressing SAMPLE or LATCH keys.

If sample and latch input modes are to be assigned on a group basis, this may be done by pressing the keys. This will program channels 0-4 to whatever input mode is selected. The same holds true for channels 4 through 7. The K500-D will seek out these channels, no matter where they appear in sequence, and assign them sample or latch input modes.

The ability to assign sample or latch input mode on a per channel basis provides an extra measure of flexibility. For instance, it may be desired to ignore any asynchronous glitches (those noise spikes that are not synchronous with a sample clock edge), except on one or two channels. This per channel assignments gives that flexibility.

Refer to Figure 3.3.13. In the Sample mode, the unit will ignore threshold transitions between active clock edges. This mode finds greatest use when recording in synchronous logic systems. Synchronous logic makes decisions at active system clock edges and is immune to logic changes that occur between those clock edges.

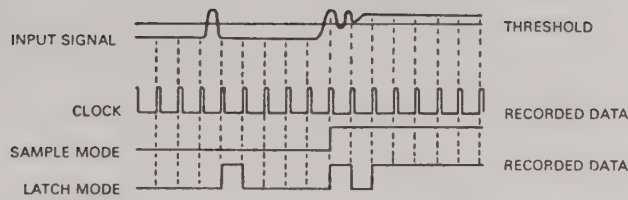


Figure 3.3.13 Sample and Latch Input modes, and an illustration of how each mode affects the data recorded in memory.

Asynchronous logic is not externally clocked, and responds to virtually any threshold transition within its speed range even if it is noise. Knowing when narrow noise spikes exist in an asynchronous logic system is of great value. The latch mode detects and flags in the analyzer's memory any threshold transitions that occur between the clock edges. The K500-D can detect glitches or noise spikes as narrow as 2 ns, with a voltage overdrive of 25% of total voltage swing or 250 mV, whichever is greater, no matter which clock period is selected. Latch mode is non-functional when a 2 ns clock is selected. The sensitivity of the latch mode is depicted in Figure 3.3.14. Note that the specification is not stated in terms of absolute voltage levels, but rather a percentage of voltage swing. This is important in those logic systems, namely ECL, where, as the clocking rate of the logic increases, the total voltage swing on either side of the threshold decreases. Thus, the glitch capture capability is in reality only related to the percentage of voltage overdrive rather than a finite voltage swing.

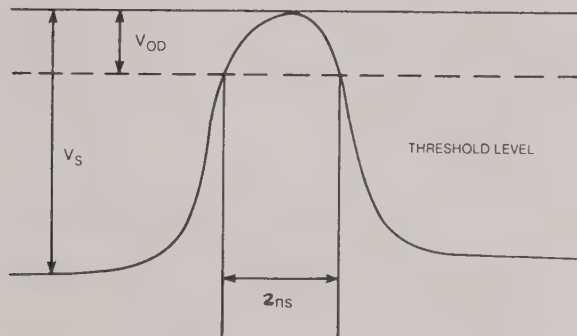


Figure 3.3.14 A graphical illustration of the Latch mode specification, which is related to percentage voltage overdrive rather than a finite overdrive. V_{OD} is 25% of V_S . The same is true for negative-going glitches.

Noise spikes between clock edges are flagged in memory as pulses represented as being two clock intervals wide, opposite in state to the previously clocked state. Figure 3.3.13 illustrates the treatment of an input signal with both the sample and latch modes, and what effect these information modes have on the actual recorded information.

The latch mode indicates the presence of noise spikes, or glitches, and their time occurrence relative to the other recorded information. The period of the noise spike is not indicated by the latch mode flag, the measurement of the glitch is limited to the time value of one memory cell. Even though the actual width of the glitch cannot be measured, its presence is recorded to provide very definite information for diagnosing a problem in the system.

PROMPTER: Select latch mode for channels 3 and 4 only, the rest of the channels will remain in sample mode. Assumptions: Default (power-up) with the STATUS displayed, all inputs are in sample.

Press:

INPUT

,

CURSOR

(until the cursor bar is under channel 4),

LATCH

,

(now the cursor is under channel 3)

LATCH

,

ENTR

.

Use the cursor keys to move the bar and re-enter erroneous parameter entries.

3.3.16 Analog Recording

An analog waveform recording can be made whether a digital or analog trigger event is selected. All parameter selections are made the same way for either type of recording.

To make an analog recording, use the analog probe provided with 10 M Ω /13 pF input impedance. This probe divides the input voltage by 10. Prior to probing the circuit, set up the analog-related parameters (offset & volts/div). Press the ANALOG key; the word ANALOG will replace DIGITAL on the upper left side of the CRT.

The range of the input is selected by pressing the ANALOG - V/DIV key. Select the 2, 4 or 8 V range by selecting 0.5, 1, or 2 V/DIV, respectively. The offset voltage is selected in increments of +1 V from +5 V to -5 V by pressing the ANALOG - OFFSET key. Both OFFSET and V/DIV keys can be thought of as menu switches. Continue to press them until the required value appears in the respective field on the lower right portion of the CRT. After the offset and sensitivity have been specified, a recording can be made. The analog signal enters a 4-bit ADC, the ADC's output goes to 4 channels of memory. The channels used are 0 to 3 for analog information. The other 4 channels record digital information if required. That gives the user the ability to correlate analog and digital events in real time relative to a system clock (synchronous recording).

3.3.17 Scroll Mode Recording

Probing hard to get at places is often time consuming and frustrating. Attaching up to 10 digital probes in a small area can be troublesome. Scroll mode eliminates those problems. An 8 channel digital recording can now be made one channel at a time.

Typically, one would connect channels 0 to 6 plus TQ (or less) to test points where a trigger word can be derived. Set up the status parameters just as if a regular recording was about to be made. Press the TIMING key to display timing on the CRT. Press SCROLL ; a recording can now be made. Touch the channel 7 probe to the point to be recorded and press the arm switch down. A single channel of timing data will appear near the top of the CRT. Press the step scroll key and the next point can be recorded. Arm the unit again and repeat until 8 points are recorded and 8 channels of timing data fill the CRT. To re-do any point, press the step scroll key until the line number next to the questionable point appears as reverse video, then re-record.

Each point can be assigned a line number from 00 to 99 by pressing the appropriate white keys when the line number appears in reverse video. When no line numbers are assigned, the unit will start at 00 and increment by 1 for each new recorded line. There are two scroll modes, auto scroll and step scroll. In auto scroll, the unit will increase the line number by one count and make the recording on the next line. In contrast, step scroll mode requires the user to press the step scroll key to move to the next line; then the user can select a line number. Line numbers will increment by 1 if no line number is entered.

To assign line numbers, enter the selected line number here (8) using the white keys (0 to 9). Line numbers 0 to 99 may be entered. The line number selected appears in reverse video.

Scrolling makes it easy to record 8 channels of digital data one at a time.

- 1) The SCROLL ON/OFF key change the regular time domain display to the unique scroll mode display.
- 2) Arming the unit makes a recording on the first line.
- 3) The step scroll key moves the reverse video down to a new line (01). Arming the unit again makes a second recording.
- 4) Fill up the screen with 8 recordings. Press the step scroll key to move the reverse video down the screen; when it reaches the bottom, it bounces back to the stop. AS in reverse video means the unit is in auto scroll and the STEP SCROLL key need not be pressed. Press the STEP SCROLL key to move out of auto scroll. Move the reverse video to a line with an erroneous recording and record over the old recording.

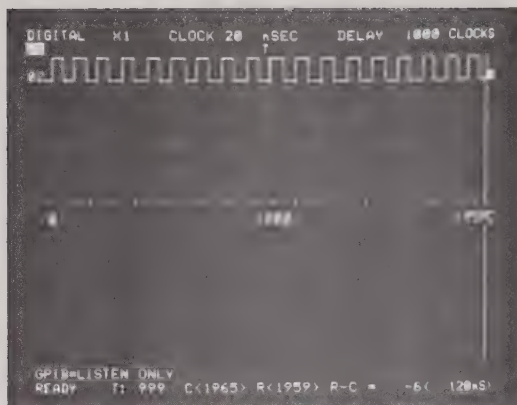


Figure 3.3.15 A Individually recorded channels using the K500-D's unique scroll mode.



Figure 3.3.15 B Individually recorded channels using the K500-D's unique scroll mode.

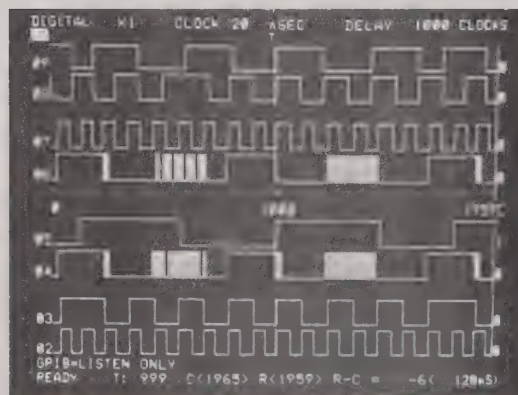


Figure 3.3.15 C Individually recorded channels using the K500-D's unique scroll mode.

PROMPTER:

Make an 8 channel recording in scroll mode. Assumed: probes 0 to 6 are connected to 7 points that can combinationally enable and trigger the recording (fewer channels will do). The status parameters are selected as if a regular 8 channel digital recording was about to be made.

Press:

TIMING

,

SCROLL

STEP

On/Off

Use Probe 7 Arm

to probe first test point Button Down

Until AS (auto scroll) appears under the word DIGITAL in the upper left corner of the CRT (Figure 3.3.15 A)

A recording appears

STEP

Move probe 7 ARM

on line 01 (Figure 3.3.15 A)

to the 2nd test point Button Down

A recording appears on line 02 (Figure 3.3.15 B)

...

repeat until all lines are filled (Figure 3.3.15 C)

3.3.18 Occurrences During Recording

After the probes are connected to the circuit under test, and all the appropriate status parameters have been selected, the unit is ready to be armed. At the lower left corner of the CRT a record status word indicates what the K500-D is doing.

3.3.19 Record Status Word

A status word will appear at the lower left corner of the CRT, in all displays.

Record Status Word Description

READY

The recording has been completed. The data may be reviewed or the status changed. The unit is ready for an Arm event.

TRGHO OK

This indicates either the K500-D is flushing its memory (trigger holdoff in preparation for making another recording. Flushing the memory means filling it with zeros. Auto flush can be disabled by setting an internal DIP switch. See Section 3.3.3.1); or the K500-D is not receiving the Clock when operated in the external clock mode. TRGHO is most noticeable when using a slow internal clock (1 ms).

ENAB?	If the K500-D is programmed for a combinational Enable event, it means that the instrument has not yet detected it, but has been Armed and is looking for the enable event.
TRIG?	If the K500-D is programmed for a combinational Trigger event, it means that the instrument has not yet detected it, or it is waiting for a Manual Trigger, but the enable event has occurred.
DELAY	The K500-D is counting out the user selected delay (Clocks or Events).
NOTE:	This record status occurs only after the memory has been flushed and the enable and trigger words have been found.
BUSY	The K500-D is processing data for display. No recording occurs at this time (in hardware).
TRIGGER HOLD-OFF	When the unit is armed, it has not started to look for the enable event. The unit must be filled with data which requires 2000 clocks to occur. This is called trigger hold-off, and can be disabled by an internal DIP switch (see Section 3.3.3.1).

3.3.20 M→A, Truncated Recordings

During normal K500-D operations, the unit completes a measurement, transfers the data from the record (M) memory to the display memory (A) and puts the data on the CRT. A complete measurement requires that a record clock be present for the duration of the measurement, including enable, trigger, and trigger delay.

In some cases when using an external clock, the clock may cease activity before the measurement has been completed. This may be due to a normal system function or a failure. When this occurs, the data existing in M may still be of interest for analysis.

The M→A key allows you to transfer the contents of M into A for display. You can record a short burst of data, press M→A, and view it. You can record and display a second burst in the same fashion. The second burst will be displayed following the first, provided the total number of clocks received during the two bursts is less than 2000. This preserves all of both bursts in memory.

3.3.21 Data Manipulation After Recording

After a recording is made, several options are open to the user: inspection of the data as data characters at 2000 memory locations; reviewing the data in a time domain format; or if the recording does not reveal the needed information, the user can make another recording.

3.3.21.1 Making Another Recording

Another recording is sometimes required when the first recording was made with too great or small a time resolution, if the recording captured the wrong portion of the data stream, or if an incorrect parameter was selected. Parameter fields such as clock rate, delay and sequence (without polarity) can be accessed with the data or timing display on the CRT; all others must be accessed with the status display on the CRT.

Clock and delay may be changed quickly with the time or data display on the CRT allowing the user to adjust resolution (clock) and

move the data window (delay), in order to home in on the exact recording required. This is similar to the microscope adjustments of resolution (focus) and moving the slide around to find the desired view.

After the parameters are corrected, just press ARM to make a new recording.

3.3.21.2 Data Display

Once the required recording is made, the data can be reformatted using the sequence parameter field. Press DATA for the Data display to appear on the CRT, then SEQ to open the sequence field.

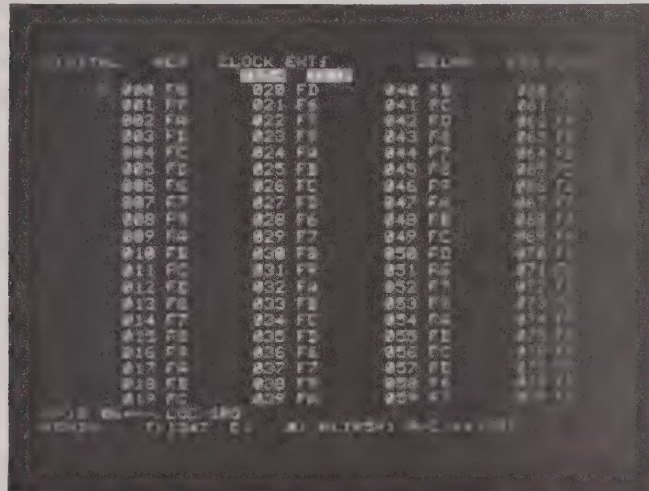


Figure 3.3.16 The default condition is the hex formatted display. To format the channels in hex after another format was selected, press the HEX key.

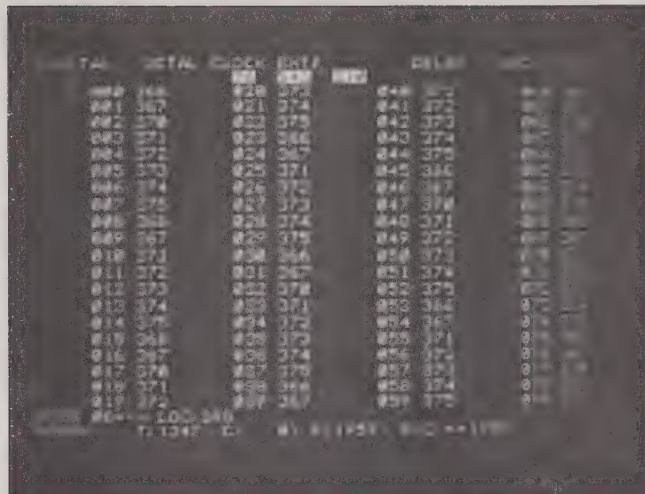


Figure 3.3.17 Press the OCTAL key, to format the data in octal. The two stand alone octal bits are always on the far left.

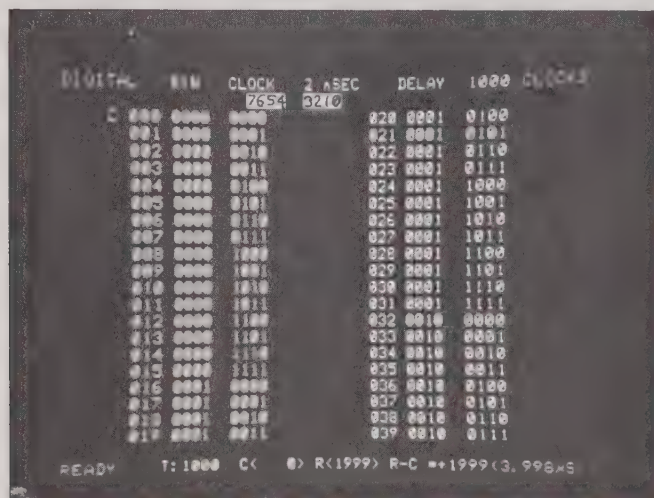


Figure 3.3.18 Press the BIN key to display all 8 bits as ones and zeros.

The SPCL is the most flexible of the data formats. The user can display a combination of binary, octal, hex or ASCII characters, simultaneously. Grouping of bits next to each other without spacing determines the format; a single bit is displayed as binary bit; 2 or 3 bits are displayed as octal characters, 4-6 bits are displayed as hex characters and 7 bits are displayed as ASCII characters, if the 7 bits are not defined in the ASCII standard, the display is binary, lower case is indicated by < >, i.e., <F> is f.

PROMPTER: Display bits 7 to 1 as ASCII character, channel 0 is not displayed.

Assumed: a recording has been made.

Press:

 ,

 ,

 ,

 ,

 ,

 ,

 ,

 ,

 ,

 (until all other channels are deleted),

 .

FORMATTING

Data is formatted in binary, octal, hexadecimal or ASCII when the BIN, OCTAL or HEX keys are pressed. If negative logic format is required to make the data more understandable, then negative polarity in the sequence field must be selected prior to the recording with status displayed. (i.e., recordings of a GPIB interface require negative logic).

CURSOR USAGE

The cursor is the vehicle for viewing different sections of the data stream. The cursor location is always displayed in the left-most column of the data display. By moving the cursor through the memory the display changes.

There are two methods of moving the cursor. The first is continuous and slow and is used to visually search the memory. Press the (C) cursor keys to move the cursor through the memory on a continuous sweep. The cursor key can be manually pulsed to move the cursor one location at a time or held down to make a slow but continuous move. The second way of moving the cursor is by jumping. Press

then either of the (C) cursor keys to open the cursor parameter fields (reverse video). Enter a new cursor location with the white numeral keys (0 to 9), then press ENTR . Cursors are used to view the data in both timing and data display. In status display it is used to move a cursor bar which allows entry of individual parameters once a parameter field is opened. Move the (C) cursor to memory location 592. Press:

, (CURSOR)

 or

 ,

 ,

 ,

 ,

 .

3.3.21.3 Searching

It is possible to visually search the memory for the occurrence of a single word from 1 to 8 bits wide. The K500-D has its own micro-processor to do this job automatically. The user can select a search word of 1 to 8 bits. Then in the data mode, an asterisk will appear next to the data locations where the search word is. The search word can contain X (don't care) bits, or the user can choose not to display various bits; in that case they won't be searched for.

PROMPTER: Search for 0100 XXXX (4X in hex).

(X is don't care)

Press:

STATUS

,

SEARCH

4hex

,

X

,

ON/OFF,

X

,

X

,

X

.

Note: 4hex is the same as

0

1

0

0

in binary (black keys)

The search word has been entered.

Press:

DATA

,

SEARCH

ON/OFF

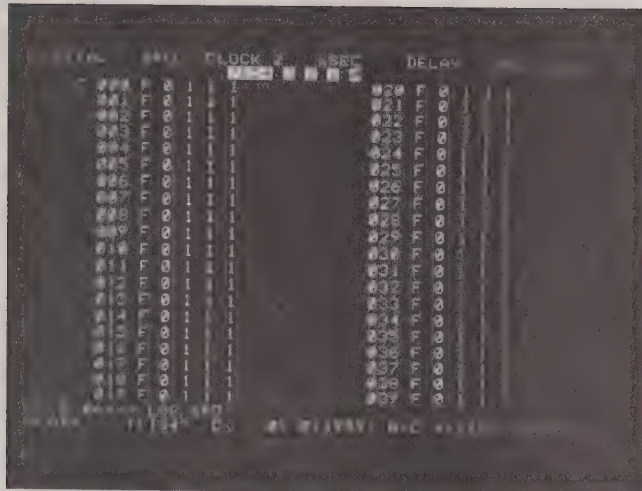


Figure 3.3.19 Press the SPCL key to use the special formatting.

The search word has been entered.

Press:

DATA

SEARCH

ON/OFF



Figure 3.3.20 The CRT displays the number of occurrences of the search word, and locations of the first, next, and last occurrence.

STEP SEARCH

Pressing the Search key caused the asterisks to appear at search word locations in the memory and also caused the display to show

the total number of search word occurrences, the location of the first, next, and last occurrence on the CRT. The (C) cursor will appear next to the next occurrence of the word. Press the Search-Step key and the (C) cursor will advance to the next word location.

ADDRESS	DATA	CLOCK 2	DELAY
000	00	020	040
001	01	021	041
002	02	022	042
003	03	023	043
004	04	024	044
005	05	025	045
006	06	026	046
007	07	027	047
008	08	028	048
009	09	029	049
010	0A	030	050
011	0B	031	051
012	0C	032	052
013	0D	033	053
014	0E	034	054
015	0F	035	055
016	10	036	056
017	11	037	057
018	12	038	058
019	13	039	059

Figure 3.3.21 In the default condition, the cursor is at memory location 000. Moving the cursor down the CRT past location 019 will move the display over so that memory location 020 will appear at the top of the left-most column of data and a new data column will move into the right-most column.

DIGITAL	HEX	CLOCK 2	ASEC	DELAY	1000 CLOCKS		
060	3C	080	50	100	64	120	76
061	3D	081	51	101	65	121	79
062	3E	082	52	102	66	122	7A
063	3F	083	53	103	67	123	7B
064	40	084	54	104	68	124	7C
065	41	085	55	105	69	125	7D
066	42	086	56	106	6A	126	7E
C 067	43	087	57	107	6B	127	7F
068	44	088	58	108	6C	128	80
069	45	089	59	109	6D	129	81
070	46	090	5A	110	6E	130	82
071	47	091	5B	111	6F	131	83
072	48	092	5C	112	70	132	84
073	49	093	5D	113	71	133	85
074	4A	094	5E	114	72	134	86
075	4B	095	5F	115	73	135	87
076	4C	096	60	116	74	136	88
077	4D	097	61	117	75	137	89
078	4E	098	62	118	76	138	8A
079	4F	099	63	119	77	139	8B

TOTAL * = 64 FIRST = 65 NEXT = 69 LAST = 1871
READY T: 999 C(67) R(1959) R-C = +1892(3.764/S)

Figure 3.3.22 By pressing the SEARCH STEP key, the display changes to the above display. Notice the (C) cursor moved to the next word location (67) from (0) the default location. Next = was 67 but has changed to next = 69. Pressing Search-Step again will put the (C) cursor at 69 and set next = 71.

PROMPTER:

To jump the C cursor to position 635, press:

SPECIFY , ← or → , 6 , 3 ,
5 , ENTR .

To jump the R cursor to position 1281, press:

SPECIFY , ← or → , 1 , 2 ,
8 , 1 , ENTR .

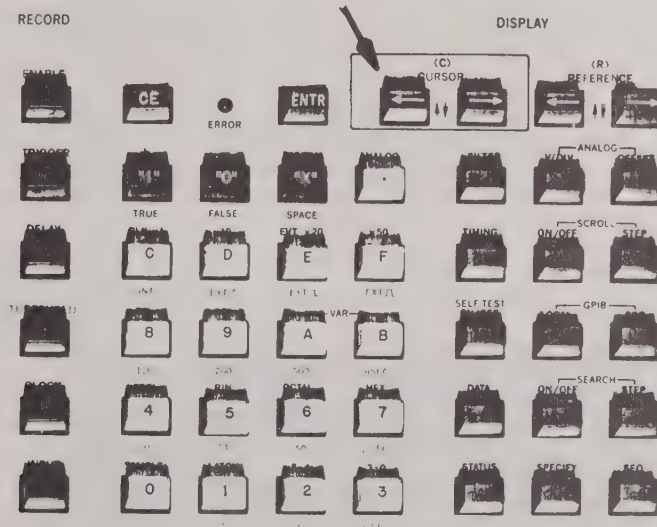


Figure 3.3.23 Keys related to moving (C) cursor in jumps are highlighted. The position of the cursor determines which portion of the memory is displayed.

3.3.22 Compare to Reference Memory

The K500-D has 3 data memories. The first is the M memory which the data stream flows through and is frozen after the unit triggers. That is a high speed ECL memory.

The second is the A memory where the frozen data is stored and accessed for display. The third is the B memory which is transferred from the A memory for future reference, or loaded via GPIB.

Typically, a recording of a known good circuit or program is made synchronously. The recording automatically is transferred from M to A memory. The recording is then moved from A to B memory via a GPIB keystroke or by pressing A→B. A second recording is now made of a questionable

circuit or program. The two recordings are then compared and a # symbol appears next to memory locations with data that is not equal in both memories. If in A memory location 0100 the data is A4 hex and in B memory location 0100 the data is A3hex, then a #symbol will appear next to location 0100 on the display; the data will also appear.

The compare mode can be used in ATE (Automatic Test Equipment) applications. An ARMing method called AUTOSTOP A=B compares the A to B memory. If A=B at all memory locations, the K500-D will re-arm, record, and make a comparison of the new A to B. This will continue until A≠B. When A≠B, the unit does not re-arm; it stops recording. The content of the "good" board or program need not be available. All reference B related controls including compare and autostop are accessible via the GPIB interface, or the front panel.

Note that asynchronous recordings do not compare well since the clocks used for the two recordings may be out of phase by up to one clock, yielding an uncertainty of one data location for all recordings.

Asynchronous Recording

First Recording

Second Recording

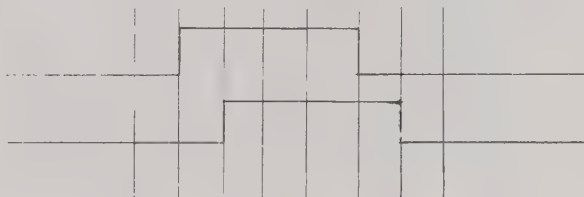


Figure 3.3.24 Both recordings are identical but are skewed by one data location. If the recordings were made synchronous, the data would look the same on both recordings.

3.3.23 Time Display

Data from all eight channels is displayed as a timing diagram.

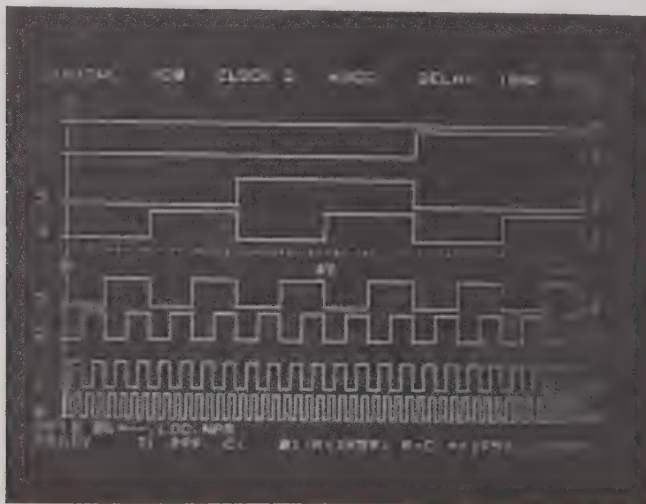


Figure 3.3.25 An eight channel timing diagram allows examination of the time relationship of several events.

The timing display is used to look at the relative positions of occurrences in real time or with respect to the system's clock. Two cursors (C) and (R) help the user examine the relationships. By placing the R on the first event and C on the other event, the exact time difference between R-C is the time period between the events. A direct time read-

out of R-C is on the lower right corner of the CRT. A typical application for the R-C feature is to measure the propagation delay of a pulse through a circuit or gate.

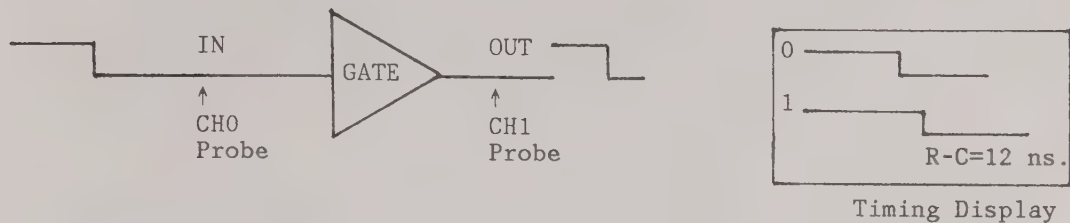


Figure 3.3.26 The propagation delay through this gate was automatically calculated when the C cursor was placed on the falling edge of the input level and the R reference cursor was put at the falling edge of the output.

Because of this capability, the K500-D is an invaluable tool to find multi-channel synchronization anomalies.

The cursors can be moved by two methods. Slowly, using the respective keys, allowing the user to finely adjust the cursor positions; the cursors can also be moved in jumps by opening the cursor parameter fields.

3.3.23.1 Formatting the Time Display

When a timing diagram is displayed, the sequence field may be opened and the order in which the channels is displayed changes. Channels may be omitted. When 4 channels are displayed, the vertical height of the channels are double that of the 5 to 8 channel display.

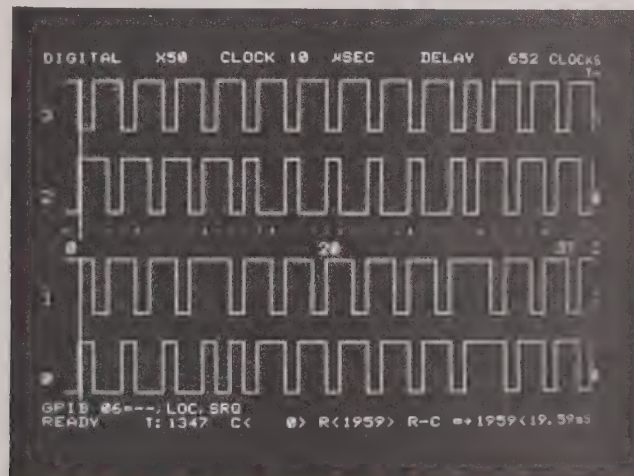


Figure 3.3.27 The four channel display is larger and easier to view than the 5 to 8 channel display. The horizontal display is 50X its original size.

PROMPTER: Display channels 0, 2, 4, and 6 with a 50X expansion.

Press:

TIMING

,

SEQ

,

0

,

2

,

4

,

6

,

ENTR

,

X50

3.3.23.2 Expansion

In addition to increasing vertical height, the timing diagram is horizontally expandable.

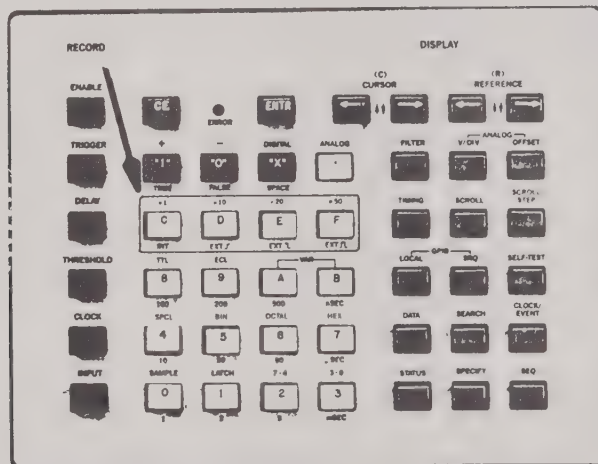


Figure 3.3.28 Horizontal expansion is accomplished with the highlighted keys.

When expanded, the C cursor position is the first memory location on the left edge of the display. By slowly moving the cursor, the entire timing diagram can be scanned. Jump the cursor to jump the displayed portion of memory.

The scenario is to look at the entire memory with an X1 expansion and move the cursor to a location, in the 2000 word memory, that is needed. Then press an expansion key to look at just the section of interest. Now move the C cursor back and forth to finely position the required data pattern.

Display memory locations 540 to 580 on the timing diagram.

Press:

SPECIFY

C

(CURSOR)

←

or

→

5

4

0

ENTR

X50

3.3.23.3 Resequencing the Timing Diagram

Logic Analysis may require comparing channels 0, 3 and 7, then channels 0, 2 and 5. The K500-D can resequence the channels, so the user can put 0, 3 and 7 next to each other, then change the display to put 0, 2, and 5 next to each other.

PROMPTER:

Sequence the timing display for a 0, 2, 4, 6, 1, 3, 5, and 7 sequence.

Press:

TIMING

SEQ

0

2

4

6

1

3

5

7

ENTR

Make 2 and 7 change positions. Press:

SEQ

(CURSOR)

←

or

→

(until the bar is under the 2),

7

(CURSOR)

←

or

→

(until the bar is under the)

7

2

ENTR

3.3.23.4

All Digital Display

Up to 8 channels of timing information can be displayed. Recordings can be made with any display on the CRT.

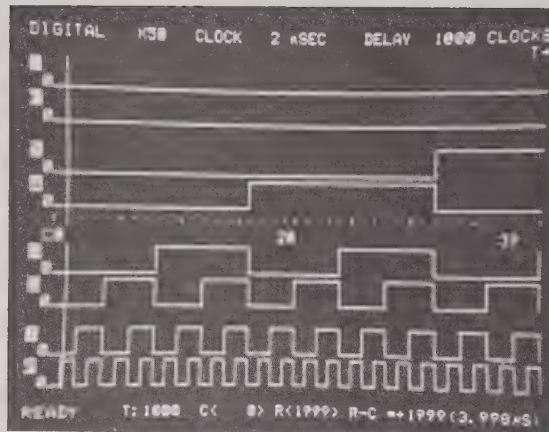


Figure 3.3.29 8 channels of timing are displayed.

That capability allows several recordings to be made quickly until the required recording is made.

3.3.24 Digital and Analog Display

Up to four digits of digital recording plus one analog recording can be displayed simultaneously, allowing the user to easily correlate digital data and analog waveshape in time domain.

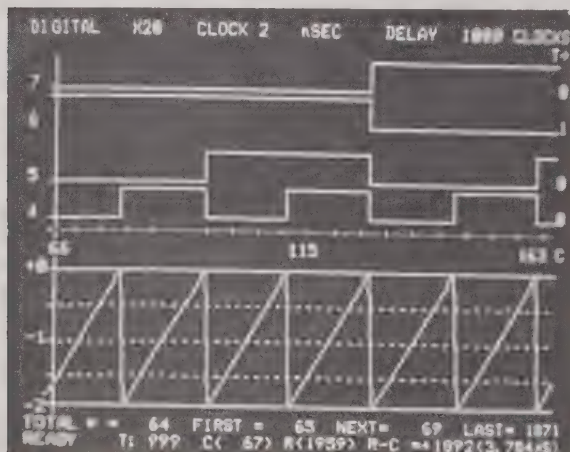


Figure 3.3.30 Digital and Analog recordings are displayed simultaneously.

The analog display appears when the unit is displaying a timing diagram and the ANALOG key is pressed. Pressing the DIGITAL key will cause the

4 analog bits output by the ADC to appear as if they were recorded digitally. Analog information will appear on channels 0 to 3.

Pressing the ANALOG key will cause the digital information on channels 0 to 3 to be displayed as an analog waveform.

3.3.25 GPIB Operation/Specifications

The K500-D GPIB is an implementation of the IEEE GPIB STANDARD 488-1978. The K500-D GPIB supports the following capabilities as defined by the GPIB STANDARD:

Source Handshake	(SH1)	Complete Capability
Acceptor Handshake	(AH1)	Complete Capability
Talker Function	(T5)	Basic Talker Serial Poll Talk Only Unaddress if 'MTA'
Talker Function with Address Extension	(TE0)	No Capability
Listener Function	(L3)	Basic Listener Listen Only Unaddress if 'MTA'
Listener Function with Address Extension	(LE0)	No Capability
Service Request	(SR1)	Complete Capability
Remote Local Function	(RL1)	Complete Capability
Parallel Poll Function	(PP0)	No Capability
Device Clear Function	(DC1)	Complete Capability
Device Trigger Function	(DT1)	Complete Capability
Controller Function	(CO)	No Capability

IFC Message

The IFC message will clear the K500-D GPIB Interface. The Talker, Listener, and Serial Poll States are set to idle, as defined by the GPIB standard. If the K500-D is in the process of transmitting a talk record when an IFC occurs, the remainder of the record will be output next time the K500-D is addressed to talk. If the operator wishes to start sending a new record after an IFC, send a command record with the desired talk record command code.

Device Trigger Message

The K500-D provides a positive-going TTL level pulse at the "GET" BNC connector on the K500-D back panel.

Device Clear Message

The K500-D will be reinitialized when it receives a DEVICE CLEAR universal message. The K500-D will also be reinitialized if it receives a SELECTED DEVICE CLEAR when it is listener addressed.

All device dependent messages sent or received by the K500-D are coded according to the record formats specified in this section. The record type used depends on the type of information to transfer. Records which can be sent by the K500-D when it is a talker, will be referred to as 'talk records'. Records which can be received by the K500-D, when it is a listener, will be referred to as 'listen records'.

The K500-D record types are:

Keystroke Record	K500-D keystrokes: represented as ASCII character codes. Talk and Listen Record.
Memory Record	K500-D measurement data: each sample represented by two hexadecimal digits. Talk and listen record.
Command Record	Commands that control the K500-D GPIB functions. Listen Record.
Status Record	GPIB Status Byte information, and the K500-D recording status. Talk Record.
Display Record	A string of characters to display on the K500-D screen. Used to print on the CRT. Listen record.
TON Display Record	A copy of the characters displayed on the K500-D CRT. Talk record.

All of the information sent in a record is ASCII encoded. Separator characters may be inserted in a record to improve readability. The K500-D recognizes ASCII spaces and commas as separator characters, except in DISPLAY records. There is no limit to the size of listen records. However, the K500-D talk records do not exceed 80 characters. All records begin with a record type character, and end with a terminator character. K500-D records may be terminated with a 'CR', or a 'CR' 'LF'. The terminator character(s) used for K500-D talk records are selected by the GPIB SELECTION switch, or by a command code sent in a COMMAND record. K500-D listen records can be terminated either way.

3.3.26 Rear Panel Switches

There is a DIP switch on the back panel of the K500-D which is used to select the device address, the GPIB "Mode", and the terminator character. Switches 1 through 5 select the device address for Talk/Listen Mode. An address from "0" "1Ehex" can be selected. "1Fhex" is interpreted as an unlisten command, so it cannot be used as a device address. When switch 6 is on, the K500-D is in Listen Only Mode. When switch 7 is on, the K500-D is in Talk Only Mode. When switch 6 and 7 are both off, the K500-D is in Talk/Listen Mode. If the TON and LON switches are both on (switch 6 and 7, respectively), the K500-D is configured in Talker Only Mode. When the GPIB mode is changed to Talker Only, the Listener State and Service Request State are set to idle. When the GPIB mode is changed to Listener Only, the Talker state and Service Request State are set to idle. Switch 8 is the terminator switch. When switch 8 is on, the K500-D will terminate talk records with 'CR' and 'LF'. When switch 8 is off, talk records will be terminated with a 'CR' only.

The GPIB selection switch may only be changed when the K500-D is in the local state.

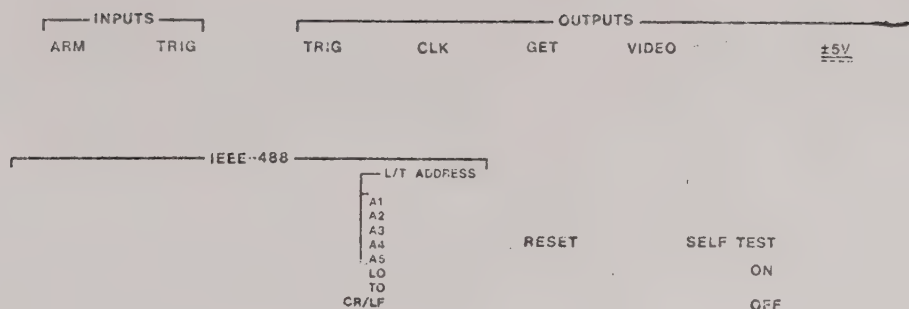


Figure 3.3.31 The 8 in-line DIP switch labeled L/T address select the bus address, the mode and line terminator. When the switch is down on the side marked open, it is a zero. Switches A1 through A5 are the address switches with A1 as the LSB.

A6	A7	
0	0	Talk only
1	0	Listen only
1	1	Listen Talk

3.3.27 Line Terminators

Lines output on the bus can be terminated by CR or CR and LF. When switch A8 = 1, the output is terminated by CR, when A8=0, the output is terminated by CR/LF. The terminators can be selected via the GPIB; if so, the GPIB command takes precedence over the DIP switch position.

3.3.28 Modes

Several different modes of operation are usable on the bus. Modes include, talk only, listen only, and talk/listen. A benefit of the K500-D interface is that two K500-Ds can talk directly to each other via a GPIB cable, without a controller.

If the units are in talk only (TO) and listen only (LO), and connected by a GPIB cable, the talker can load data or status parameter (set-up) information directly into the listener when the user presses the SRQ key. This feature is valuable for implementing remote logic analysis, where the cable is in effect lengthened by bus extenders, modems and telephone lines allowing the users to transfer data and set up parameters over virtually any distance. The unit can be switched from LO to TO or TO to LO without changing the data or status.

A second talk only mode (TON) is enabled with an internal DIP switch. When enabled, the unit will output whatever appears on the CRT to a printer (if the printer is GPIB compatible and on the same bus). When the unit is displaying a timing diagram, it will not be outputted. However, the data display that would appear if the DATA key was pressed will be outputted. Another K500-D will not understand the TON output.

The K500-D Options Dip Switch is located in the K500-D chassis, on the Data Display Board. Switch 5 is the GPIB TON switch. The position of this switch determines the type of record sent by the K500-D when it is in Talker Only Mode (TON).

When the switch is on, the K500-D will send a series of TON DISPLAY records.

When the GPIB TON SWITCH is off, the type of record sent depends on the display mode of the K500-D. In Status Mode, KEYSTROKE records are sent. In Data and Timing Mode, the K500-D sends MEMORY records, and a KEYSTROKE record with cursor values and the Data Mode display key.

3.3.28.1 Talk and Listen Mode

LISTENER: When the K500-D is in Remote State, it will process device dependent messages sent to its listen address. The device address is selected by the GPIB SELECTION switch. Four types of records may be sent to the K500-D when it is addressed to listen: KEYSTROKE records, MEMORY records, COMMAND records, and DISPLAY records.

TALKER: When the K500-D is addressed to talk, it will send the type of record requested by the last command record. In some cases, the requested data will take more than one record to send. In this case, the K500-D will send one record each time it is addressed, or as long as it is addressed, until all of the requested data has been sent. After all of the requested data has been sent, the K500-D will not send anything, even if it is continually addressed to talk.

3.3.28.2 Talk Only Mode

LISTENER: The K500-D has no listener capability in this mode.

TALKER: The K500-D will send out information when the GPIB SRQ key is pressed. The type of information sent depends on the position of the GPIB TON switch, and the display mode of the K500-D. When the GPIB TON switch is on, the K500-D will send a copy of the K500-D screen, except if Timing Mode is displayed, in which case a copy of Data Mode is sent. The characters displayed on the screen are sent as TON DISPLAY records. Twenty TON DISPLAY records are required to send the Status Mode Display, 24 are required to send the Data Mode display.

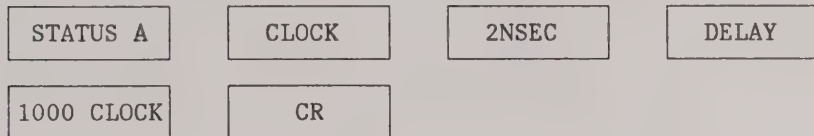
When the GPIB TON switch is off, the type of records sent depend on the display mode of the K500-D. In Status Mode, the keystrokes for setting up the currently displayed record parameters are sent. The keystrokes are sent in four KEYSTROKE records. In Data and Timing mode, the K500-D sends two types of records. MEMORY records are sent containing the measurement data from the memory locations between (and including) the cursor and reference locations. The K500-D will send as many MEMORY records as are necessary. The last record is a KEYSTROKE record, containing the keystrokes for setting up the current cursor and reference cursor values, and the keystroke for generating the Data Mode display.

3.3.28.3 TON Display Output

This record is sent by the K500-D under the following conditions: Talker Only Mode, the GPIB TON SWITCH is on, and the SRQ key has been pressed. The K500-D will send one TON Display Record for each row of characters displayed on the K500-D screen. If the K500-D is in Status Mode, 20 records will be sent, one for each row of the K500-D Status Mode display. If the K500-D is in timing or data mode, 24 records will be sent, one for each row of the Data Mode display. This record is provided so that a picture of the current K500-D screen may be sent to a printer. This type of record will not be recognized by another K500-D.

The first character of a TON display record is a '.' (decimal), the record type. The next 42 characters are the ASCII characters displayed on one row of the K500-D screen.

This is an example of a '.' record:



Note that if the screen is displaying a timing diagram when the SRQ key is pressed, the output will be the same as if the unit were displaying data. No timing diagram can be output via the GPIB. A video output is provided for that purpose.

```
.DIGITAL  HEX  CLOCK 2  .SEC  DELAY  1000 CLOCKS
.          7654  3210
.    C 000 00      020 14      040 28      050 30
.    001 01      021 15      041 29      061 3D
.    002 02      022 16      042 2A      062 3E
.    003 03      023 17      043 2B      063 3F
.    004 04      024 18      044 2C      R 064 40
.    005 05      025 19      045 2D      065 41
.    006 06      026 1A      046 2E      066 42
.    007 07      027 1B      047 2F      067 43
.    008 08      028 1C      048 30      068 44
.    009 09      029 1D      049 31      069 45
.    010 0A      030 1E      050 32      070 46
.    011 0B      031 1F      051 33      071 47
.    012 0C      032 20      052 34      072 48
.    013 0D      033 21      053 35      073 49
.    014 0E      034 22      054 36      074 4A
.    015 0F      035 23      055 37      075 4B
.    016 10      036 24      056 38      076 4C
.    017 11      037 25      057 39      077 4D
.    018 12      038 26      058 3A      078 4E
.    019 13      039 27      059 3B      079 4F
.GPIB=TALK ONLY
.READY  T: 999  C<  0> R<  64> R-C = +64( 128.S)
```

Figure 3.3.32 A GPIB compatible printer printed the above. The printer was interfaced to the K500-D via a GPIB cable. The K500-D had TON enabled (DIP switch position #5=1 on the data display board) and was in the (TO) Talk Only Mode. The SRQ key was pressed, while the above data was on the CRT.

```

.STATUS A          CLOCK 2   .SEC    DELAY  1000 CLOCKS
.MODE DIGITAL      FILTER OFF  V/DIV 0.5    OFFSET -1V
"
.SEQUENCE          7654  3210.          T C
" /POLARITY +++++ +++++          Q K
"
.ENABLE (A) T XXXX XXX1          X
"
.TRIGGER (D) T XXXX XXX1          X
"
.THRESHOLD         EEEE EEEE          E E
"
.INPUT MODE        SSSS SSSS
"
.SEARCH            XXXX XXX1
"
.ARM MODE          AUTO
.GPIB=TALK ONLY
.READY            VAR A -1.30V    VAR B +1.40V

```

Figure 3.3.33 When the display was changed to Status mode and the SRQ key was pressed, the above figure was printed by the printer, with the TON switch enabled.

```

K*5$C#1#B#C#L#D#0#1#0#0#0#C#L#IF2V006$Q#7#6#5#4#I#I#3#2#1#0#J#I#I#I#I#I#L
K$Q#G#G#G#G#I#I#G#G#G#G#L$E<#G#I#I#I#I#I#I#I#G#I!2
K$TC<#G#I#I#I#I#I#I#I#G#I#JC<#G#I#L$H#9#9#9#9#9#9#9#9#9#9#9#9#L
K$I#0#0#0#0#0#0#0#0#0#0#L$S#I#I#I#I#I#I#I#I#G#LAA$Y#A#H#1#J#3#0#B#G#1#J#4#0#L$TW

```

Figure 3.3.34 The above figure was printed by a GPIB compatible printer linked to the K500-D via a GPIB cable. The TON switch was disabled and the unit was in talk only. The display was STATUS and the SRQ key was pressed. The print out describes the keystrokes required to duplicate the front panel set-up. When input to another K500-D, the STATUS parameters are programmed into the second K500-D.

```

M00000000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E1F20212223
M00362425262728292A2B2C2D2E2F303132333435363738393A3B3C3D3E3F4041424344454647
M007243494A4B4C4D4E4F505152535455565758595A5B5C5D5E5F606162636465666768696A6B
M0108606D6E6F707172737475767778797A7B7C7D7E7F808182838485868788898A8B8C8D8E8F
M0144909192939495969798999A9B9C9D9E9FA0A1A2A3A4A5A6A7A8A9AAABACADAEAFB0B1B2B3
M0180B4B5B6B7B8B9BABBBCBDBEBFC0C1C2C3C4C5C6C7C8C9CACBCCCDCECFD0D1D2D3D4D5D6D7
M0216D8D9DADBD0DDDEDFE0E1E2E3E4E5E6E7E8E9EAEBECEDEEEFF0F1F2F3F4F5F6F7F8F9FAFB
M0252FCFDFEFFF000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E1F
M0288202122232425262728292A2B2C2D2E2F303132333435363738393A3B3C3D3E3F40414243
M03244445464748494A4B4C4D4E4F505152535455565758595A5B5C5D5E5F6061626364656667
M036068696A6B6C6D6E6F707172737475767778797A7B7C7D7E7F808182838485868788898A8B
M03968C8D8E8F909192939495969798999A9B9C9D9E9FA0A1A2A3A4A5A6A7A8A9AAABACADAEAF
M0432B0B1B2B3B4B5B6B7B8B9BABBBCBDBEBFC0C1C2C3C4C5C6C7C8C9CACBCCCDCECFD0D1D2D3
M0468D4D5D6D7D8D9DADBD0DDDEDFE0E1E2E3E4E5E6E7E8E9EAEBECEDEEEFF0F1F2F3F4F5F6F7
M0504F8F9FAFBFCFDFEFFF000102030405060708090A0B0C0D0E0F101112131415161718191A1B
M05401C1D1E1F202122232425262728292A2B2C2D2E2F303132333435363738393A3B3C3D3E3F
M0576404142434445464748494A4B4C4D4E4F505152535455565758595A5B5C5D5E5F60616263
M06126465666768696A6B6C6D6E6F707172737475767778797A7B7C7D7E7F8081828384858687

```

Figure 3.3.35 A GPIB compatible printer, interfaced to a K500-D via a GPIB cable printed the above figure. The TON switch was disabled, the unit was in (TO) Talk Only and the SRQ key was pressed.

Figure 3.3.35 is the format of the memory transfer of one K500-D talking directly to another. Thirty-six memory locations are included on each line. Location 0612 to 0647 inclusive are on the last printed line. The unit outputs all the A memory data between the cursors. Memory location 0612 has 64hex, 0613 has 65hex.

3.3.28.4 Listen Only Mode (LON Mode)

LISTENER: The K500-D will process any message sent across the GPIB. It will not look for its listen address before attempting to process a device dependent message.

TALKER: The K500-D has no talker capability in this mode.

3.3.29 Keystroke Control

The first character of a keystroke record must be a "K". The next group of characters are the keystrokes. Each keystroke is represented by two ASCII characters. This is an example of a "K" record: K, *S, #1, #B, #C,\$L, \$D, #1, #5, #0, #C, #L, CR, LF (See Figure 3.3.34).

In addition, to the keys available on the K500-D keyboard, a group of "pseudo" keys are provided. Some of the pseudo keys are required to take the place of "Toggle" and "Rolling" keys. These are keys which cycle through a range of predetermined values when they are pressed. A pseudo key is provided for each value that these keys can select. The other pseudo keys provide functions in addition to those available from the K500-D keyboard.

3.3.29.1 Keystrokes

The keycodes are grouped according to their use. The first character of the keycode is a group code. The keys are grouped as follows:

Type of Key	First Character
Function of Key	\$
Value Key	*
Display Mode Key	!
Record Control Key	#
Cursor Key	C
Reference Cursor Key	R
GPIB Key (SRQ)	G
Scroll Key	S
Pseudo Key	No Group Code

Description of Key	Keycode
Enable	\$ E
Trigger	\$ T
Delay	\$ D
Threshold	\$ H
Clock	\$ C
Input	\$ I
Search	\$ S
Specify	\$ Y
Sequence	\$ Q
0 1 Sample	# 0
1 2 Latch	# 1
2 4 7-4	# 2
3 MSEC 3-0	# 3
4 10 SPCL	# 4
5 20 BIN	# 5
6 50 Octal	# 6
7 USEC HEX	# 7
8 100 TTL	# 8
9 200 ECL	# 9
A 500 VAR A	# A
B NSEC VAR B	# B
C INT X1	# C
D EXT R X10	# D
E EXT F X20	# E
F EXT D X50	# F
"1" TRUE +	# G
"0" FALSE -	# H
"X" SPACE DIGITAL	# I
ANALOG	# J
CE	# K
ENTER	
STATUS	* S
TIMING	* T
DATA	* D

Figure 3.3.36 K500-D Keycodes

Description of Key	Keycode
Auto Arm	! 0
Manual Arm	! 1
Auto Enable	! 2
Manual Enable	! 3
Auto Trigger	! 4
Manual Trigger	! 5
M to A	! 5
Stop	! 7
Cursor Left	C <
Cursor Right	C >
Reference Cursor Left	R <
Reference Cursor Right	R >
Scroll Mode	S M
Scroll Step	S S
Search Step	E S
Pseudo Keys: Datamode Search Off	S 0
Datamode Search On	S 1
Filter Off	F 1
Filter On	F 2
Volts Per Division = .5 V	V 0
Volts Per Division = 1 V	V 1
Volts Per Division = 2 V	V 2
Offset = +5 V	O 0
Offset = +4 V	O 1
Offset = +3 V	O 2
Offset = +2 V	O 3
Offset = +1 V	O 4
Offset = 0 V	O 5
Offset = -1 V	O 6
Offset = -2 V	O 7
Offset = -3 V	O 8
Offset = -4 V	O 9
Offset = -5 V	O A
Arm Mode Manual	A M
Arm Mode Auto	A A
Arm Mode Ext	A E
Blank K500-D Display	B D
Transfer Status W to Status A	T W
Display A	D A
Display B	D B
Transfer A to B	A B
Autostop when A=B	N 0
Autostop when A≠B	N 1
Autostop when A=B within limits	E 0
Autostop when A≠B within limits	E 1
Compare A to B (On)	B 1
Compare A to B (Off)	B 0

Figure 3.3.37 K500-D Keycodes (Continued)

3.3.29.2 Pseudo Keys

"S0" and "S1" pseudo keys: The SEARCH key on the K500-D keyboard has different functions in Status mode and Data mode. In Status mode the SEARCH key selects the search field. In Data mode, the SEARCH key turns SEARCH off if it is on, and on if it is off, (Toggle Key). In Status mode, use the standard Key "\$S" to select the SEARCH field. In Data mode, use the SEARCH mode on with the pseudo key "S1". Turn SEARCH mode off with the pseudo key "S0".

"F0" and "F1" pseudo keys: These pseudo keys replace the toggle key FILTER. To turn the FILTER off, Use the "F0" pseudo key. To turn the FILTER on, use the "F1" pseudo key.

"V0", "V1", and "V2" pseudo keys: These pseudo keys replace the rolling key V/DIV. "V0" selects 0.5 volts, "V1" selects 1.0 volt, and "V2" selects 2.0 volts.

"00" through "0A" pseudo keys: These pseudo keys replace the rolling key OFFSET. To select the OFFSET value in the range of +5.0 volts to -5.0 volts, use pseudo keys "00" to "0A", respectively.

"AM", "AA", "A ", and "AE" pseudo keys: The K500-D has three ARM modes: Manual, Auto, and External. Depressing the ARM MANUAL or ARM AUTO key will display the ARM mode, and initiate a record cycle. External ARM cannot be selected by a key, the K500-D will arm externally whenever an external arm pulse is present. In order to display the Status mode of one K500-D on another K500-D, it would be desirable to display the ARM mode without arming the instrument. The pseudo keys "AM", "AA", and "AE" are provided for this purpose. The fourth ARM mode is Autostop where the unit will automatically re-arm itself until a recording is made that meets the stop criteria (i.e., A=B, A≠B or limited comparison between C and R cursors).

"TW" pseudo key: The K500-D has two sets of recording parameters. "Status W" contains the parameters for the next recording. "Status A" contains the parameters used for the last recording. New parameters entered in Status Mode automatically go into "Status W". If you want to set the "Status A" parameters, you must use the "TW" pseudo key after the new parameters have been entered. This pseudo key transfers the "Status W" parameters to "Status A".

"BD" pseudo key: This key will blank the K500-D screen. The only message regenerated after blanking is the GPIB Status Message. To regenerate the K500-D display, send one of the Display Mode keys in a "K" record.

3.3.29.3 Keystroke Output

The K500-D talks and listens to the same characters. When commanded to output status parameter (set-up) or data information the unit will output the same characters needed to attain the set-up or data in memory when in the listen mode. For the commands that tell the unit to output keystroke and memory data onto the bus (see section 3.3.33 Commands).

3.3.30 Memory Access

Memory data can be input or output via the GPIB, provided that the TON switch is set properly. The formats for input and output are identical.

The first character of a Memory Record must be an "M", the record type. After the "M", the next character selects the memory (A or B) to change. Use ASCII "A" or "B". The next group of four characters are the begin-

ning memory location of the measurement data. The memory location field must be four ASCII Digits, "0" through "9". There are 2000 samples of measurement data in the K500-D memory, referred to as memory locations "0" through "1999". The remainder of the record is the measurement data. Two ASCII characters represent the DATA for one memory location. The first character is the hexadecimal value for the data recorded on Channels 7 through 4. The second character is the hexadecimal value for the data recorded on Channels 3 through 0. If an analog signal was recorded, the second character will contain the binary code value of the signal. The legal ASCII characters in the Memory Data Field are "0" through "9", and "A" through "F".

This is an example of an "M" record: MA, 0025, 2F, 2E, 03, 03, FA, FA, CR, LF

At address 0025 data is 2F, at 0026 data is 2E and so on.

MA, 0031, A2, B0, B1, F7, 56, 78, CR, LF might be on the next line of data.

For the command that tells the unit to output memory data onto the bus see Section 3.3.33.

3.3.31 Status Byte

The first character of a Status Record must be an "S". The next group of eight characters represents the value of the GPIB STATUS BYTE. The value of each bit of the GPIB STATUS BYTE is encoded as an ASCII "0" or ASCII "1". The value of the MSB (bit 8) is given first, down through the LSB (bit 1), which is last. A comma starts the next field, The "K500-D Recording Status" field. The Recording Status describes the current state of the K500-D recording cycle. The first character in this field is the Recording Status Code, A number between "0" and "7". The next five characters are the Recording Status message that is displayed in the lower left corner of the K500-D Status Mode display.

K500-D Recording Status Code

0	READY
1	BUSY
2	---
3	TRGHO
4	CLK?
5	DELAY
6	ENAB?
7	TRIG?

This is an example of an "S" Record, shown with spaces for clarity:

S 0 1 0 1 0 0 0 0 , 0 , READY CR

For the command that tells the unit to output the status byte onto the bus see Section 3.3.33.

3.3.32 Service Requests

If the K500-D has requested service from the controller, the "SRQ" bit (bit 7) of the Status Byte will be set as defined by the GPIB STANDARD. The "SRQ" Bit will remain set until the controller performs a Serial Poll. The other Status Byte bits indicate the reason service was requested. The K500-D will request service under the following conditions:

- 1) End of K500-D record cycle
- 2) "SRQ" key pressed when in Remote State
- 3) Error in K500-D power-up diagnostics
- 4) GPIB listen record error (see following table)

The Status Byte bits have the following meaning:

BIT #	DECIMAL VALUE WHEN THIS BIT SET	MEANING
8	128	1=END OF RECORDING CYCLE
7	64	1=K500-D SERVICE REQUEST (RQS BIT)
6	32	1="SRQ" KEY PRESSED
5	16	1=ERROR IN POWER-UP DIAGNOSTICS
4	8	BITS 4 THRU 1 ARE USED FOR A LISTEN RECORD ERROR CODE. SEE "GPIB LISTEN RECORD ERROR CODES".
3	4	
2	2	
1	1	

GPIB LISTEN RECORD ERROR CODES

- | | |
|---|---|
| 0 | No error |
| 1 | K500-D ERROR LED was or is on (keystroke not valid at this time) |
| 2 | Illegal record type. Result: Whole record ignored |
| 3 | K record: Illegal keycode. Result: Keycode ignored |
| 4 | M record: Starting Memory Location out of range. Result: Last digit in "Starting Memory Location" field ignored |
| 5 | M record: Illegal character in "Starting Memory Location" field. Result: Character ignored |
| 6 | M record: Illegal character in "Memory Data" Field. Result: An ASCII 0 is used |
| 7 | M record: Illegal character for memory select, must be "A" or "B". |
| 8 | C record: Illegal command code. |
| 9 | D record: Illegal character. |

3.3.33 Commands

The first character of a Command Record must be a "C", the record type. The next character or group of characters are Command Codes. K500-D GPIB commands fall into three groups. The first group of commands tells the K500-D what type of record to send next time it is addressed to talk. The second group of commands tells the K500-D what character to use to terminate K500-D talk records. The third group tells the K500-D whether or not to assert the "EOI" signal along with the last character of a talk record. Each command is one ASCII character. Any number of commands may be sent in one record, however, only the last command from each group will be processed. This is an example of a "C" record: C, M, R, E, CR, LF.

K500-D GPIB COMMAND CODES

TALK RECORD COMMAND CODES

- | | |
|----|---|
| SR | Send a Status Record (S record). |
| PA | Send the keystrokes for setting up the K500-D "STATUS A" record parameters. |
| PB | Send the keystrokes for setting up the K500-D "STATUS A" record parameters. |

DW	Send the keystrokes for setting up the K500-D "STATUS W" record parameters. (K records)
MA	Send the measurement data from the memory locations between and including the cursor
MB	and reference cursor location. The cursors can be in any order, and at any location. If the the cursors are at the same location, that location will be sent. (M record(s))
CU	Send the keystrokes for setting the cursor and reference cursor to their current values. (K record)

TERMINATOR COMMAND CODES

TC	Terminate K500-D talk records with a "CR".
TL	Terminate K500-D talk records with a "CR", "LF".

EOI COMMAND CODES

E1	Assert the "EOI" signal with the last character of a talk record.
E0	Do not assert the "EOI" signal.

3.3.34 Printing a message on the CRT

This record displays a string of characters, starting at a given location on the K500-D screen. The position of the message is given as a row and column. There are 52 columns across the screen. In Status Mode, there are 20 rows down the screen, in Data and Timing Modes there are 24 rows down the screen.

The first character of a Display Record must be a "D", the record type. The next four characters are the row and column positions. Two ASCII Encoded decimal digits are used for the row, and two digits for the column. The range of row values is "1" through "20" in Status Mode, and "1" through "24" in Timing and Data Modes. If the range of the column is out of range, a value of "1" is used. The remaining characters constitute the message to be displayed. Any printable ASCII character may be used, including the space and comma characters. If an unprintable or illegal character is included, a "?" is displayed. The row and column positions will be automatically incremented until the end of the screen is reached. If there are still more characters to display, the remainder of the message will be printed starting at row 1, column 1. This is an example of a "D" record: D,01,05, THIS MESSAGE WILL DISPLAYED ON THE K500-D SCREEN. CR

3.3.35 GPIB Status Message on CRT

GPIB hardware is installed in the K500-D chassis, the status of the K500-D GPIB is displayed in the lower lefthand portion of the K500-D screen. The only time the message is not displayed is when Search Mode is on and Data Mode is being displayed. The search mode information is displayed in the same area as the GPIB Status Message.

In Listen Only Mode, the message is:
GPIB = LISTEN ONLY

In talk Only Mode, the message is:
GPIB = TALK ONLY

In Talk/Listen Mode, the message format is:
GPIB 01=TA, LOC, NPR
(where 01 is the K500-D bus address)

The Talk/Listen Mode message fields are:

1) The Device Address

2) The Talker State and Listener State

Message	Talker or Listener State
" "	TIDS OR LIDS (IDLE)
"TA"	TACS, TADS, OF SPAS (ADDRESSED)
"LA"	LACS, OF LADS (ACTIVE)

3) The Remote Local State

Message	Remote Local State
LOC	Local State
LWL	Local With Local Lockout State
REM	Remote State
RWL	Remote with Local Lockout State

4) Service Request State

Message	Service Request State
NPR	No Service Request Pending
SRQ	Service has been Requested

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